# POWER PLANT ENGINEERING

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## Old Man River

CERTAINLY the gentleman shown above should know a great deal about rivers. Night after night after night he has listened to the mighty voice of Paul Robeson in Show Boat telling him all about Old Man River: what he does and how "he don't say nothin,' he jus' keeps rollin' along!" For the gentleman above is none other than Charles Winninger, the famous star of Show Boat.

What he is doing in the Westinghouse research laboratories, where the above picture was taken, we don't know. Neither are we sure why he is so much interested in the two machines used there for testing fatigue of metals, one machine, the world's largest, for a specimen 2.25 in. in diameter, the other the world's smallest, for an 0.55-in. specimen. But we hazard the conjecture that this authority on rivers is thinking what a fine thing it would be if there were some sort of device to measure the fatigue of rivers.

Just think how tired a river must get—even a good strong one—carrying along the usual tremendous load of sticks, leaves, mud, defunct cats, mismated rubber boots, old newspapers and orange peelings.

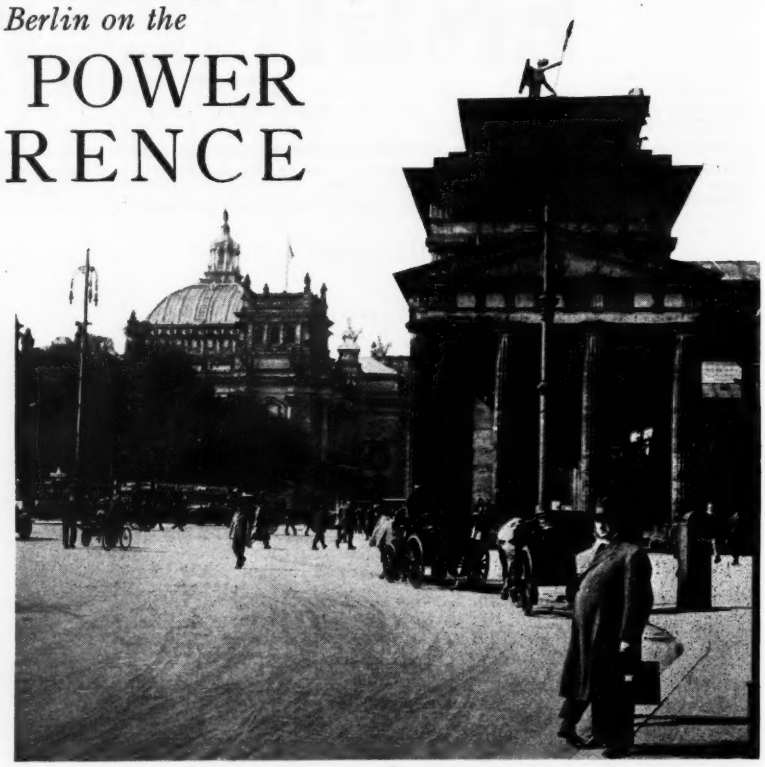
Well, of course, we do what we can to lighten the load of Old Man River before we try to put him to work in the condenser. He can't condense steam while he's carrying that load of leaves, cats and miscellaneous junk referred to above. We try to help him deposit it, however, by providing a suitable screen house.

All this costs money. But on page 862 of this issue, Mr. Streiff tells us some of the ways in which we can help Old Man River work for us and at the same time reduce the costs.

*A. L. Rice, Editor of Power Plant Engineering*
*Reports from Berlin on the*

# WORLD POWER CONFERENCE

ELECTRICITY IN AGRICULTURE AND INDUSTRY, DR. EINSTEIN ON SPACE VS. MATTER, POWER RESOURCES, MARINE PRACTICE, POWER SYSTEMS WERE THE HIGH LIGHTS



AT THE OPENING reception, delegates were welcomed by Herr von Kardoff, vice-president of the Reichstag, in the Reichstag Hall, complimenting Lord Derby on his successful work and wishing him further success, in politics, business, social life and sport, especially at the Ascot meeting. He expressed the hope for a successful meeting, for the satisfaction of all visitors and that they carry away the thought that the German people wish only to live in freedom and friendliness with all the world, which the Conference might serve to further.

Lord Derby expressed his pleasure at being present and that the Conference, started in England as the first great international gathering to bring together representatives of nations shortly before in arms, had grown to great standing, with committees in 50 countries, over 2000 representatives present and with sectional meetings already held in Switzerland, Spain, Great Britain and Japan.

In presenting the gavel to Herr von Miller, Lord Derby wished him even greater success in carrying on the work of the Conference, a fitting capstone to a life of great accomplishments, among which one of the greatest has been the establishment of the Deutsche Industrial Museum, completed in 1928.

Dr. von Miller in reply spoke of his 50 years' work as an engineer, starting with pioneer long-distance transmission of power from Lauffen to Frankfurt. Meetings of the Conference give opportunity for interchange of ideas tending to further similar advances and progress throughout the world. Personal contact, interchange of experience, discussion of problems, formation of friendships as well as a showing of the advances made in Germany in science and development of power resources were features offered by the Second World Power Conference to which he bade visitors welcome, with the hope that they would always look back on it with pleasant memories.

At this session, after review of the work done and to be done by Dr. von Miller, and addresses of welcome by Chancellor Dr. Bruning and Mayor Scholz of Berlin, replies were made for different sections of the world. Sir Charles A. Parsons spoke for Great Britain; George Magnier, President of the French Committee; Director L. Tolloczko for Poland; Professor Krajewski for Russia; General Director Gosta Malm for Scandinavia; Dr. H. J. van der Bijl for Africa; Dr. Charles Camsell of Canada for No. America; Sr. M. S. Rodriguez of Brazil for So. America; Dr. Masano Kamo for Japan and the far East; Dr. A. C. Rivett for Australia and New Zealand; Dr. Carl Koettgen for Germany and central Europe.

Music was furnished during the session by the orchestra of the State Opera in whose auditorium the meeting was held.

## FIRST TECHNICAL SESSIONS

Electrification of a large farm, having 17-hp. oil engine and its own 3-phase and direct-current distribution system was contributed by R. H. Drilhou of France. Twenty stationary motors are installed with lighting either alternating or direct current.

Application of motors for pumping to drain and to irrigate in Italy and Greece; of refrigeration for storage and electric heat for hatching and cooking silk cocoons in Japan; on heating of hot beds, by cables, using up to 220 v. in Norway, Sweden and Austria; and summary of domestic uses of electricity in the United States by Marshall E. Sampsell gave a perspective of the field now being and to be covered. Standardization, reduced cost,

and such arrangements as will improve load factor, seem to be the problems requiring most attention.

In the session on production and preparation of fuels, increasing mechanization of collieries was brought out, also that the greatest problem in coal separation is in separation of ash, to reduce cost of transport and clinkering. In seeking better heat economy, the user is asking for suitable brands and specifications, trending toward national and international agreements as to nomenclature for coals and methods of sampling and analysis.

### Dr. Einstein Speaks

Dr. A. Einstein spoke Monday afternoon on The Space Field and Ether Problem in Physics. He stated that while experience of the senses gives rise to conceptions of space, our conceptions of space and of systems are never strictly a product of sense experience. When we think of material objects, a most important element for comprehending the laws of position, as in geometry, is the idea of their touching. On this are based ideas of form and measurement. Grecian geometry was the first attempt to formulate from abstractions such as the elements of form, point, line, plane, a logical system from which shapes and relative positions of objects could be constructed. This did not, however, cover conception of space extent and form which was introduced by Descartes into modern geometry, making it possible to describe geometrical figures by mathematical analysis. Conception of space was based on the idea of study of position relative to one body such as the surface of the earth or the sheet of paper on which plane figures were drawn, rather than on relative position of bodies to each other. The one body, used as a reference point for measuring position is, however, a fiction of an indefinitely extended body with which all others can be brought into contact.

But the introduction of Descartes' thought of space extent and form made possible formulation of Newton's laws of mechanics, space, in Newton's theory being a physical reality. It had the property that it could exert influence, but nothing could influence it. It was a limitless, unchangeable container of all things, present and future.

Newton considered space, time and ponderable matter but in the 19th century, after discovery of the wave nature of light by Young and Fresnel, a fourth element, ether, was thought necessary, an inert substance filling all space, to transmit vibrations. Even though this conception broke down with the Faraday-Maxwell theory of magnetic field action, which could not be explained as a mechanical state of the ether, electromagnetic fields were still conceived as states of the ether, which no longer was thought of as a material substance. How easy to say that electromagnetic fields are states of space, space and ether being one and the same thing! That it was not done was because space was considered as a rigid framework, so to speak, subject to no influence, hence not a carrier of variable states.

The law of propagation of light in empty space, with the principle of Relativity as regards uniform motion resulted in uniting space and time into a four dimensional entity, since it was realized that the conception of simultaneous events represents nothing real. To such a four-dimensional space, some system of dimensions has to be attributed, analogous to the three-dimensional Euclidean space, but using an imaginary time coordinate.

Since nothing is absolutely stationary and velocity and acceleration are only relative, it was obvious that the conception of inertia corresponded to nothing real. The problem became to express the laws of four dimensional space mathematically and this constitutes the formal theory of Relativity. Space, instead of being fixed, is subject to change of state and to influence and has become analogous in structure to a magnetic field. The equations to express the laws must cover both gravitational and electromagnetic influence on space. Dr. Einstein stated that these field laws now seem to have been found and are actually in agreement with experimental laws of gravitation and electricity to the first degree of approximation. Further investigation is needed to determine whether these field laws provide a

FIG. 1. KROLL OPERA IN BERLIN, MEETING PLACE OF SECOND WORLD POWER CONFERENCE

useful theory of material particles and their movements.

Hospitality was showered on delegates at all times. All the great plants in and around Berlin were opened, government officials, engineering societies, private firms and individuals doing everything conceivable for the comfort and interest of visitors. Even mention of the various functions and trips would take more space than can be allowed. It must suffice to state that the arrangements were complete and carried out with characteristic German efficiency.

### Electricity in Crafts and Industry

Electrochemical manufactures, heating, welding and efficiency in lighting and machine driving were included in the discussions in this section. Increase in output, better efficiency in use and products for which the power cost is a small percentage of the total are the developments in electrochemical work. The extent of the work is indicated by use of 2000 million kw-hr. a year in Italy and 1700 million kw-hr. a year in Germany, with currents running up to 40,000 amp. for some processes,

FIG. 2. REICHSTAG BUILDING WHERE OPENING SESSION AND RECEPTION WERE HELD

which involves large capacity equipment. Transformers of 32,000 kv-a. are now in use and larger ones are probable.

For heating, use in metallurgical work is increasing especially for such work as making spongy iron, high-grade steel and other alloys and precise control for special tempering. Working processes in off-peak periods and thermal storage by hot water for laundries and domestic heating have raised the load factor, decreased the cost of using electricity and will permit further extension of electric heating.

For electric welding, the automatic arc process is showing advantages as improving efficiency and uniformity of the weld. For some work, however, resistance welding shows a saving in time and a smaller seam.

Electric filtering for precipitating solid and liquid particles from gases, the purpose being, recovery of material, improvement of industrial gas or purification of waste gas, is finding considerable use. Direct current at high voltage from hot cathode tubes or copper-exide rectifiers is needed, also gases must be precooled and moistened. Dr. R. Seeliger in his paper gave full details as to German practice.

That suitable lighting increases the comfort and output of workers is well known. Several papers described tests now being used to determine the best method of lighting for various operations and the resulting rules that are being formulated as a result. Results from Russian laboratories and from German factory tests were given.

Motor-drive for machines is developing in Germany by special construction of the motor for its work, one or several motors being used for different functions of each machine, depending on its size and complexity. The purpose is to provide such equipment for driving, starting and speed control as will permit the best use of the machine, cost of equipment and economy of power being considered of less importance than bettering the quality and quantity of output.

### Fuel Power and Heat Resources

As in the United States, coal is the chief source of power in Europe, water-power predominating only where fuel is poor and scarce. For Germany, 33 1/3 per cent of the power is hydroelectric. Siberia has 85 per cent steam plants. Poland depends largely on natural gas. Russia is utilizing peat with moisture 30 to 45 per cent and heat value of 3250 B.t.u. per lb. This is burned in suspension, pulverizing being unnecessary. Some high-volatile coal is used, also oil for peak loads. Preheated air at 250 deg. has increased efficiency by seven per cent. Supervision of operation is entrusted to a government heat laboratory which also designs new plants.

Ample power supply seems to be available. The problems are for generating and transmitting with greatest economy and without restriction of power supply between countries. No country is independent as to its energy supply and free flow of energy is needed for best economy. As the supply of liquid fuel is limited, conversion of solid into liquid fuel is of greatest importance.

Centralization of generation and increase of power networks has developed and will continue, especially where cost of shipping low-grade fuels makes generation at the mine mouth desirable.

A novel proposition was the use of dried water hyacinth, found in large quantities in semi-tropical and tropical countries, as a fuel. Its removal from waterways would aid navigation and its growth is rapid, estimated at the rate of an equivalent of two million tons of coal a year in the southern Asiatic countries.

### Coördinated Research

While the subjects reported upon in the research session covered a wide range including availability and the utilization of solid and liquid fuels, steam properties of wind energy, all reports showed the trend to organize research so as to avoid duplication of effort and equip- and heat transmission, hydraulic tests and availability ment and to carry on industry by more scientific methods. Also international coöperation, giving the benefit of results to all and exchanging ideas as to methods, data needed and problems to be solved, is making for more rapid progress in discovery of facts and their application in practice as evidenced by the recently promulgated table of international standard values for properties of steam.

Papers at the power economics session raised many interesting points. A suggestion was made for driving steam turbines in Arctic regions with low-boiling-point

hydrocarbons in place of steam, deriving the heat head from difference in temperature in winter between water under the 20-ft. ice layer and the winter air and using sea-salt solution as the condensing medium. Estimates were for plant cost $56.30 per kw., working period 120 days a year, current cost at bus bars ½ to 3 cents per kilowatt-hour.

Another proposal was transmission of hydroelectric power from Norway into Germany over a 620-mi. line at 380,000 v., the estimate being a cost of $23 per kilowatt-year for 750,000 kw. or, on a basis of 6500-hr. use, a cost of 0.36 cents per kilowatt-hour.

A paper on research as related to power development will be abstracted later at length.

Safety problems both as to provision for continuous operation of plants in case of strike or emergency and as to accident prevention were discussed. Papers from Russia told of the method of measuring the effect of increased use of power on effectiveness of workers, the results showing the same as for other countries; also an argument, sociological rather than engineering, as to the effectiveness of state against individualistic system of production.

### Load Factor and Generation Costs

On this subject, G. H. Jones pointed out that study shows fuel cost per kilowatt-hour to be minimum at a load factor 70 to 75 per cent, but fixed charges decrease up to load factor of 90 per cent and total cost curve is parallel to the fixed charge curve. Below 75 per cent, fixed charge per kilowatt-hour is greater than fuel cost.

To increase load factor, three methods are available: Increasing hours of use of customers; new uses diverse from present load; develop special rate schedules to increase diversity of use. Of these, increase of diversity of use by many is preferable to adding a few large customers with high load factor.

Electric refrigerators and motors for oil burners give the largest domestic loads, each about 400 kw-hr. a year. Off-peak water heating uses some 360 kw-hr. a year per house, a good arrangement being a 500-w. element for steady load with a 1000-w. element cutting in for peaks. Storage heating from 11 p.m. to 6 a.m. for house heating has been found profitable, while air conditioning for theaters helps out summer load.

Interconnection is helping to join up non-coincident peaks and to bring on rural service whose peaks vary from those of city demand.

Other authors discussed methods of determining load factor, character of various groups of customers and their variation with seasons and weather, also the effect of yearly variation on transformer and substation losses as determining the system and kind of current to use in making plant extensions. Suitable rates to fill up valleys rather than attempt to reduce peaks was considered advisable. Some proposed were promotional rates for off-peak domestic service with maximum demand control, special rates for low power factor and for long-hour use. Care must be used, however, that cost of service is covered under all conditions and that new peaks are not created, displaced from former peaks, as has occurred in some instances.

Advances in marine practice were fully treated but little was brought out applicable to stationary practice. Steam at pressure of 525 lb. and temperature of 750 deg. F. is assured and the Hamburg-American Line is testing the desirability of the Benson boiler with 3000 lb. pressure. Stokers, pulverized fuel, air preheating are being tentatively used. Larger power plants and better efficiency are sought, over-all efficiencies as high as 27.5 per cent being now obtained.

In the use of Diesel engines, double-acting construction, supercharging, high speed and higher leaving temperature of cooling water to allow better utilization of waste heat are some of the trends. Marine practice is coming to coincide with land practice as to Diesel engines and it is estimated that over-all efficiency of 38.3 per cent may be obtained.

Since auxiliary drives take 15 to 20 per cent of the total power on shipboard and are for the most part electrically driven, efficiency of their prime mover plant is important and is given careful study in new designs.

### Power Supply Systems

Of special interest were the plans reported for extension of the national system in Russia. State power

FIG. 3. VIEW NEAR GARDASEE, TYPICAL OF THE SCENERY FOR WHICH GERMANY IS FAMOUS

stations in 1933 are expected to have capacity of 5,300,000 kw., 73 per cent of all capacity in Russia. Transmission lines at 20 to 220 kv. will be 12,000 mi. and 82 per cent of the energy used will be from state plants. From 1923 to 1929, the annual rate of increase in power use was 22 per cent. At the close of 1929, the state station capacity was 892,000 kw. with 2,586,000 kw. under construction, and transmission lines were 2500 mi.

Use of Diesel engines to help carry the peak load of steam stations is increasing, a notable example being the 11,700-hp. engines in the Hofsburg station of the Berlin municipal system.

In most countries, a national grid for interconnection is being developed under a general plan but there is a question as to how far transmission of large amounts of power will be profitable as, above a certain station capacity, increased size has little effect in reducing fuel cost, which is 50 to 80 per cent of production cost in the United States. One proposal, made by Dr. -Ing. Oskar Oliven as to a super-power system for all Europe, will be described at length later.

Two addresses by Americans featured the American

FIG. 4. OLD HOUSES AND WATER-WAY IN HAMBURG, GERMANY

Hour meeting, preceded by a message of good will from President Hoover to the Conference.

One address by the American Ambassador, Mr. Sackett, concerning the ratio between retail price and switchboard operating cost of current was typical of the loose thinking, careless statement and seeking for striking effect so often heard in general public addresses, especially those made for semi-political effect. The other by H. Foster Bain was the opposite: a carefully prepared analysis of conditions, the relation of cause to effect, developments now taking place and to be expected and what part minerals, their production, exhaustion of known present supply and development of new supplies and new metals will play in the future use of power. Mr. Bain's address is well worth careful reading but space does not permit its publication here.

### Large Power Plant Planning and Operation

Careful planning of the whole system and making the plant fit into this plan was emphasized by several authors, the plan to be based on estimates from past progress. Probable load curves and arrangement of boiler and generator units to operate economically on the loads indicated are necessary in laying out a plant, a special department of the organization being preferable for this work. The chief considerations must be reliability, simple operation, best economy, reasonable cost, good voltage regulation on the supply network and possibility of extension of the system. Study of practice and theory shows no constructional difficulties in using extra high pressures and temperatures up to 850 deg. F.

As to reserve units, opinion differs as to whether to keep some units in service at less than full load to handle instantaneous peaks or to use a design which permits quick starting for emergencies. One novel proposal is keeping the reserve turbines warmed by circulation of hot air, the heat necessary for a 30,000-kw. turbine being equivalent to 280-kg. an hour of steam as compared to 9000 for no-load running. Bringing in a cold turbine takes too long for emergency peaks if excessive expansion strain is to be avoided.

Effort at removing impurities from flue gases in England were reported, special washing towers for coal at Battersea station having apparent success in removing sulphuric acid and dust. Also two examples were given of successful washing at the mines to remove dirt and sulphur, the cost of the process being largely offset by reduced costs in transportation, in handling of coal and ash and in the pulverizing of the coal.

### Large Electrical Apparatus

Papers dealt at great length and in detail with problems of stresses, cooling, capacities, weights, speeds and regulation for generators, transformers, motors and rectifiers. Weights are being reduced and capacities increased in the latest units, the limits being set by admissible electric, magnetic and mechanical stresses. Use of high strength alloy steels, also methods of design and machining to reduce residual stress are employed. Reducing losses and improving ventilation are means used to advance the heating limitation. Efficiencies up

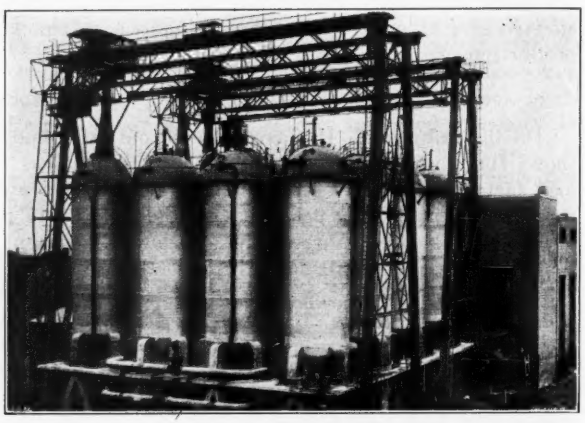


FIG. 5. STEAM ACCUMULATORS AT CHARLOTTENBURG STATION

to 97.9 per cent for 2-pole and 97.3 per cent for 4-pole machines are being attained, while hydrogen cooling is giving promising experimental results, although packing at the shaft presents difficulties. Short-circuit stresses are being reduced by the use of two independent windings but this involves complication in the transmission system.

It is considered that considerable increase is possible in future capacities, up to 250,000 kv-a. for 4-pole machines at 1500 r.p.m. It may be necessary to build up cores and wind stators at the plant on account of transportation difficulties.

In the effort to improve power factor on lightly loaded networks, compensation of individual motors of 10 to 600 kw. has probably gone too far for economy, one instance being the use of large motors with low magnetic saturation in Denmark on rural systems to keep power factor at half load up to 0.9. For industrial systems special machines are expedient, the synchronous motor being used in America while the asynchronous machine is more popular in Europe. The latter are used up to 40,000 kv-a. but require special starting. Squirrel cage rotors, with special designs such as double slot cores are giving a starting characteristic as good as or better than slip-ring rotors.

For commutating machines, the voltage between bars,

usually limited to 12 to 15 v., has been raised by use of the disc commutator to 50 v.

Development of rectifiers has advanced rapidly, air cooling being used up to 500-amp. capacity and water-cooling up to 16,000 amp. Back-firing or reversal of current flow has been overcome by the use of a grid in front of the anode which is positively charged by a relay on occurrence of back-fire, without the circuit breaker being tripped.

The Mercury-Inverter has been developed by a Japanese firm for converting direct into alternating current through use of a slotted motor-driven disc. The same method can be used for changing voltage of direct current or frequency of alternating current.

### Coöperation of Power Plants

Papers in this section dealt with the coördination of gas and electrical works, with the object of utilizing waste from one in the other, also with the coördination of hydraulic and steam plants in a system. Savings in administration and purchasing also by low-temperature, high-temperature carbonization and electric generation in a combined plant were discussed.

N. E. Funk showed the economies of operating hydraulic plants with fluctuating stream flow in connection with steam plants. Steam plants can be located near the load centers and carry base load, while water power reserve units can be more quickly brought in than steam turbine units to help out on peaks. For peak load, a steam reserve plant is naturally expensive and with variable stream flow, a hydraulic plant is unsatisfactory for steady load. Combined operation requires, however, careful planning and control.

For best economy, the hydroelectric plant will take over the base load during high-water periods and steam will carry the peak and vice-versa for low-water periods.

As to electrification of railroads, it was argued that slow progress has been due to the capital outlay required for conversion from steam, but results have been so satisfactory that more rapid development may be expected in the future. For long heavy hauls, single-phase operation would seem to be best adapted, for shorter interurban service high-voltage direct current serves better.

In America, standardization of design and mass production of small Diesel units has been emphasized while European practice favors rather the manufacture of large engines to special specifications for each plant. In Europe, Diesel engines are considerably used for stand-by and peak loads and, for small plants, compete with steam, the 4-stroke cycle being somewhat used, while in America 50 per cent of stationary Diesels work on the two-stroke cycle with crank-case scavenging. German practice has, however, turned to the two-stroke cycle for capacities over 1000 kw.

FIG. 6. ONE OF THE AUTOMATIC BOILER HOUSES OF THE GOLPA-ZSCHORNEWITZ LIGNITE-FIRED POWER STATION

Research in the Diesel field is particularly concerned with processes of scavenging and supercharging, use of exhaust gases, action of nozzles and sprays and utilization of heat in the engine. One novel proposal was for use of water heated by jacket and exhaust gases at pressure of 1500 lb. in a uniflow type of steam cylinder arranged on the lower end of the piston of a two-stroke cycle Diesel engine.

### Steam Turbines

Noteworthy data were given of Swiss turbines for 3000-lb. pressure, having casings of molybdenum steel, blades of chrome and nickel steel, nickeled to reduce erosion. Tests by Escher Wyss have shown that for given blading and steam velocity, efficiency is independent of steam pressure but reducing the length of blades for small output lowers efficiency materially.

Another investigation on turbine models showed that no improvement in heat per kilowatt-hour was shown for pressures above 1950 lb. per sq. in., the best obtainable plant efficiency being 30.9 per cent.

English opinion was that peak demand is best met by overloading of boilers, turbines and generators.

In Austria, high-pressure steam has been found economical even for small units, an example being a 400-kw. turbine at 1655 lb. per sq. in.

Discussion of American practice was given in papers which will be abstracted at length.

In development of combined gas and steam prime movers, a new 2200-kw. experimental machine is now being developed, having gas turbine, steam turbine, air compressor and generator, the object being combustion under pressure and utilizing exhaust from the gas turbine to make steam. The arrangement is to be such that either gas turbine or steam turbine may act as the main unit for generation of electric current, according to the distribution of heat.

Use of a two-fluid cycle, ammonia at 120 lb. and steam at 330 lb. was also suggested, calculated saving over the use of steam alone at 330 lb. being 30 per cent, cost of plant being the same for both methods. An experimental plant is to be built.

### Water Power Development

Planning development for stream flow and storage plants and combination with steam plants made up most of the material of these papers. Use of propeller and Kaplan turbines for low head is increasing and their efficiency for low heads is proving equal to the Francis type. One novel method described was a plant at Gosan Lake in Austria where water level of the reservoir is lowered 120 ft. below entrance to the turbine inlets by means of a floating pumping plant. Two electrically-driven pumps discharge into flexible steel pipe lines, the floating plant falling with water level and part of the

pipe lines resting on the shore as water level falls. Water is utilized in the turbines under head of 675 ft.

In the layout of plants, simplification was emphasized, the trend being toward fewer and larger units. For Pelton wheels, such design of piping as will avoid bends and tees with spherical casings is needed to prevent whirls and eddies in the jets from the nozzles.

Provision for extreme movement of guide vanes so that a reverse torque may be exerted on the runner to act as a brake for quick stopping was suggested, tests having shown that operating efficiency is not lowered by such a construction.

### Large Power Storage

Three methods were discussed: Water in reservoirs, either natural flow or pumped up during low-load periods; hot-water storage; and storage batteries.

Germany seems to lead in pumped water storage having by the end of 1930, 600,000 kv-a. capacity in operation, the largest plant being at Herdécke for

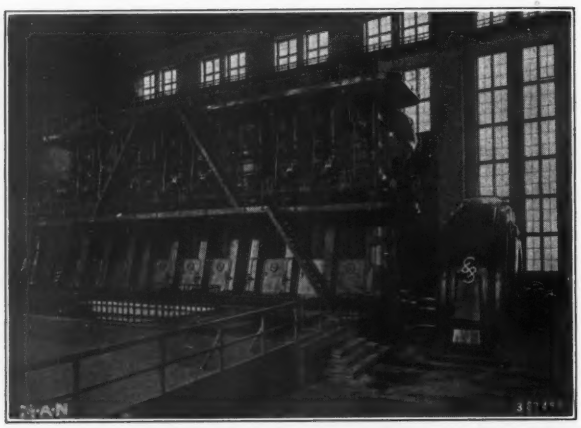


FIG. 7. LARGEST DIESEL ENGINE IN THE WORLD, THE 15,000-HP. UNIT AT NEUHOF STATION, HAMBURG

530,000 kw-hr. storage. One analysis concluded that for certain circumstances, pumped storage for a steam plant shows savings in coal. Another showed that for a plant costing $87.50 per kw. located on inexpensive land within 15 mi. of a city and with head of 735 ft. above the lower level and capacity of 2,000,000 cu. yd., for a yearly demand of 77,000,000 kw-hr. the most economical plant would be steam power with pumped storage for peak load. This depends, of course, on head available, cost of plant and nature of the peak. If conditions permit storage of natural flow, pump storage loses advantage, also if the storage must be far from the center of power consumption.

Storage of heat in water, both by the Ruths system and by accumulation of extremely hot feed water was analyzed. The best example of Ruths accumulator practice in central stations is the 67,000-kw. plant in the municipal plant at Charlottenburg. This works between 187 and 7 lb. and initial cost is stated to be only 40 per cent of that for equal capacity boiler plant. It is only one of the methods used for carrying peak, however, since the Berlin municipal system uses boiler capacity for base loads and flat peaks, Diesel engines for pronounced peaks, pump-fed storage for sharper peaks and storage batteries for maximum sharp tips of peaks. Admitting that the method of power storage must be adapted to conditions of the plant, opinion seems to favor storage of power, where possible, rather than peak load boiler plants, although it is by no means unanimous. An added advantage of storage is its availability as an emergency reserve.

### Electric Line Protection

Grounding of circuits, formerly optional, is now obligatory either by law or insurance rules, to reduce danger to life and from fire.

For the United States, the Fire Code and Safety Code prevail. In Russia the same practice is now followed but the ground connection is designed for a resistance voltage on dead ground of a line according to conditions; 500 v. for rural lines, with grounded neutral, 250 v. for insulated neutral and 150 v. for towns.

Disturbance of telephone systems and radio equipment by power lines, especially currents passing through the earth from grounded circuits varies with height of line, length of line and voltage. More knowledge is needed to estimate and overcome these effects but it is important that it be done, if overhead lines are to be used in settled districts.

Recent investigations have given much clearer knowledge of lightning effects on transmission lines. Surges due to inductive charges are dangerous only on medium voltage networks. For high-voltage systems the chief danger is from lightning actually striking the line, causing steep front surges that flash over the insulators. Transformers are seldom injured. Insulators are being developed to withstand the flashover, also new types of arresters capable of handling heavy currents and of reducing potential differences.

### Boilers and Furnaces

Papers in this section were chiefly concerned with a summary of current practice and those which will be abstracted give a quite complete picture of all.

Some Russian experiments indicate that, by using a pulverized-coal furnace and a grate to catch and burn falling particles, such fuels as waste peat, with not over 50 per cent moisture, sawdust not over 40 per cent moisture and vegetable waste can be satisfactorily burned in suspension without pulverizing.

Discussion of boilers and equipment pointed out trends toward larger sizes, simpler forms, decrease of manual labor, furnace adaptation to fuel, better materials for boilers, 0.3 per cent molybdenum steel, with or without chromium, being thought a suitable material. In size, 400 t. of steam an hour and 80 lb. of coal burned per square foot of grate per hour are on the way.

### Water Power Resources

Water powers are being developed rapidly in Canada, the increase in 6 yr. being 79 per cent so that there is now 583 hp. installed per person. Nevertheless only about ⅛ the available power has been developed. Of the total energy, 84.1 per cent is generated in central stations, 10.1 per cent in paper mills and 5.8 per cent in other industrial plants. Of the central station supply, cellulose and paper mills use 25.1 per cent. Use of storage reservoirs has extended the availability of water power in individual cases 7 to 12 mo.

In Norway, entire rivers have been diverted into other valleys to increase available power.

Italy is increasing its storage in the Alpine lakes and has 68 reservoirs with capacity of 500,000 cu. yd., corresponding to 960,000,000 kw-hr.

Portugal produces some 100,000-hp. by water power.

Austria has now storage of 168,000,000 kw-hr. and is developing plants on the Danube River for output of 5450 million kw-hr. a year.

In the Argentine, a tidal power development is proposed using 1.5 to 6.75 ft. head and driving turbines by both incoming and outflowing tides. Daily output is expected of 10,000,000 kw-hr. and delivery at Buenos Aires 900 mi. distant at 0.25 cents per kw-hr.

### Combined Heat and Power

For the most part, papers were confined to descriptions of the methods used for special industries and local conditions, especially blast furnace plants and steel mills. The possibilities for higher pressures in industrial plants were shown, also for interchange of power between public utilities and large industrial plants. The most important of these papers will be given in abstract form.

### Switch Gear and Controls

High capacity, oil-less switches and quick break are the considerations for development. Ventilation, is obtained by explosion pots and double breaks. For oil-less action, several plates are used to keep voltage at each break under 250 v., which will not break down the layer of gas formed on the cathode. Electrostatic field gives equal distribution of reaction voltage and magnetic field secures relation of arcs at individual contacts. Quick break cuts down induction effect and avoids line disturbance.

In England, capacities up to 1500 million volt-amperes are produced with 2500 m.v.a. in sight at 33, 66 and 132 kv. For over 1000 m.v.a., a separate oil switch for each phase is preferred, with two to six breaks per pole. Cast-iron, ironclad gear is used up to 66 kv-a. with 132-v. equipment being studied. Outdoor stations are most common for high voltages. Duplicate busbars with two oil switches for each high-voltage are considered important.

In German cities, switchgear is usually in stories while rural plants are horizontal. Switches are of compressed gas type, using a high velocity jet of un-ionized gas on the expansion type which converts electrons in a break into nuclei for condensation.

Development of automatic operation or from remote control of stations and substations is proceeding. The advantages are reliability, speed and reduced cost and the methods by direct relay or by relay with control drum.

Required features are distant indications of the position of switches and of performance and certainty of action of controls.

Remote control for stopping and starting with automatic action while running, even to opening and reclosing circuits and to load distribution, is found in America and Australia. In other stations, remote control of operation is practiced using an impulse system, either audible or visual, or a carrier frequency system. One conductor is often used for a variety of currents of different frequencies.

Load dispatching from a central point is becoming increasingly important with interconnection of networks, also central control of boiler and generator rooms by signalling systems or by means of relays.

In the report of the Conference at the final session, it was shown that 3900 were registered in attendance, some 400 papers were presented and some 500 discussions. Attendance at technical meetings was good at all times.

Various resolutions have been presented, which will be considered by the national committees, then by the International Executive Council.

Several proposals for increasing the usefulness of the Conference are in the hands of a Sub-Committee, among them limitation of the volume of papers to be presented, continuous exchange of power statistics between national committees, coöperation with other inter-

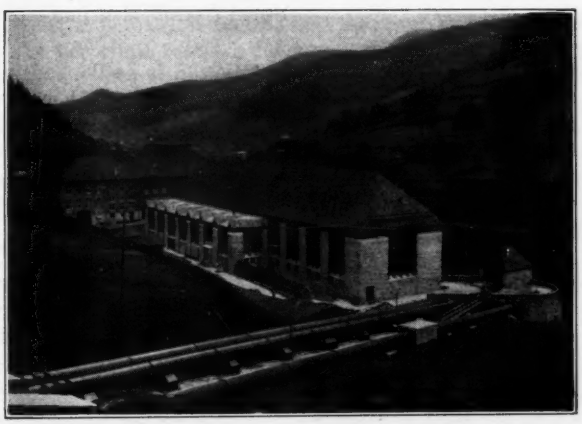


FIG. 8. THE NEW HYDROELECTRIC PLANT NEAR FERBACH, GERMANY, ON THE RIVER MURG

national organizations to avoid overlapping of interests. It is decided, however, that a World Engineering Federation or Congress would result in duplication of activities and over-organization.

One definite accomplishment at the present Conference was an agreement to compile an official list of terms used in all principal languages for gross and net calorific values of fuel with national indices of both; to request adoption of an international standard for gross and net values by standardization committees and to use every effort to have it always made perfectly clear which value is given.

Next sectional meeting is to be held in Scandinavia in 1933 on Power Supply of Big Industrial Undertakings and the third Plenary Session in 1936 in America.

As a result of papers and discussions may be visualized reduction of the cost of power generation and distribution by lower plant and system cost and by bettering load factor. One or both of these objects was dealt with by practically all papers. It was shown that increased use of power produces in the long run reduction of unemployment, because new methods of manufacture are introduced, requiring new products, new equipment, making increased demand for goods and larger markets.

One noteworthy feature was the general addresses

as to the relation of power to other fields of industrial and sociological activity and the relation of relief from hard physical labor by the larger use of power to cultural progress.

After a brief summary of activities and expression of thanks for the hospitality of German friends and organizations by Chairman O. C. Merrill of the American Committee, Herr zur Nedden gave a summary of the Conference activities.

Resolutions of thanks to German industry, the Government and the Verein Deutscher Ingenieure for their support of the Conference were introduced by L. B. Atkinson of Great Britain and Dr. Iouyé of Japan. To the German committees and especially to Dr. Koettgen, Professors de Thierry and Matschoss, Mr. zur Nedden, Dr. Dehne and their staffs for their untiring work, by E. Brylinski of France and R. Avramowitsch of Jugoslavia. To all who so abundantly offered hospitality, including individuals, the German Government, the Prussian State, the City of Berlin and all others by O. Jacobini of Italy and J. W. Meares of India. To the national committees of other countries by the German National Committee by Dr. E. L. C. Koettgen and Dr. E. L. Matschoss.

Also a telegram was sent to President Hoover expressing appreciation of his message to the Conference and the hope that he would personally participate in the third meeting in 1936.

# Fundamentals of Furnace Design

Essential Conditions of Radiant Heat Absorption, Air Supply and Mixture with Gases. By H. G. Lykken*

SUCCESS of any boiler installation is as dependent upon proper furnace design as upon any other one factor, whether pulverized coal or any other method of firing is employed. As a matter of fact, the great majority of fuel-burning difficulties and poor efficiencies encountered are traceable, in a large measure, to some inadequacy in the furnace.

Difficulties and deficiencies in the firing equipment, or in the boiler itself are concrete and easily seen. They can be readily pointed out and measured because we know better what burning equipment and boilers should be to be right. Less, however, is known about the furnace, what takes place there and how a furnace should be designed to be right from the standpoint of volume, heat release, gas travel, effect of radiant heat, necessary black surface, temperature and many other factors. As a result, little thought is given to the furnace and it is seldom right.

## Fundamental Temperature Requirements

To be right, a furnace design must be started with certain fundamental considerations that cannot be ignored.

When coal is burned with a given amount of air, we get a given amount of gas with a given temperature and per cent of $CO_2$. This temperature is the same, whether the coal is burned in suspension or on a grate. Relating the amount of air used to the per cent of $CO_2$ in the products of combustion we get the following table:

| $CO_2$ per cent.... | 16 | 14 | 12 | 10 | 8 | 6 |
|---|---|---|---|---|---|---|
| Temp. deg F.... | 4000 | 3500 | 3000 | 2500 | 2000 | 1500 |

It is, of course, desired to burn the coal with a minimum of excess air to get the best efficiency, as any greater amount of excess air carries off more heat in the flue gas, due to both the increased quantity and the higher temperature; for, the greater the gas volume and the lower the $CO_2$, the higher the stack temperature.

Assuming then that we want to operate with 14 per cent $CO_2$, we shall have a gas temperature generated in the furnace of 3500 deg. F. Such a temperature will, of course, make the ash run like water, soften the brick work and slag the tubes. It will destroy any grate or stoker.

We know also that, to avoid slagging of the tubes, the temperature of the gas entering the first pass of the boiler must be below the softening point of the ash, which, with many coals, is not more than 2000 deg. F. We know that to avoid slagging of the walls, fusion in the fuel bed or a fused mass in the bottom of a pulverized coal furnace, the temperature in those parts of the furnace must, with many coals, be 2000 deg. or less and seldom over 2400 deg. with any coal. We know further that the gas entering the first pass of the boiler should never exceed 2300 deg., to get the best efficiency out of most boiler designs. It follows, therefore, that there must be a temperature reduction in the furnace of 1300 to 1500 deg. or a drop of temperature from 3500 deg. to 2300 or 2000 deg. as the case may be, in the gas before it comes in contact with the walls or the boiler surface, if we are to operate with 14 per cent $CO_2$.

This is the first fundamental fact. There is no way to get around it. This temperature reduction must take place, or we have the alternatives, wall deterioration, slagging, burning out of grates and every other difficulty known to furnaces.

## Radiant Heat Absorption Needed

That the coal is burned in the furnace and all the heat conducted to the boiler by the gas is an old theory which no longer holds. That theory worked and works with 8 to 10 per cent $CO_2$ where the gas temperature, as can be seen in the table, is never much in excess of the 2300 deg. to begin with, due to dilution with high excess air. It will not work with a higher $CO_2$.

When operating with 14 per cent $CO_2$, 30 to 40 per cent of the heat generated must go into the water before the gas ever reaches the boiler. This amount of heat must pass from the flame or fuel bed to the boiler by radiation the instant it is generated so that we may get the corresponding drop in temperature, i.e. to prevent the temperature of the gas beyond the flame from getting above the allowable limit.

*Chief Engineer, The Strong-Scott Mfg. Co.

As a second fundamental fact, following from the first, the furnace must be so designed that 30 to 40 per cent of the heat generated passes to the boiler by radiation. Only on that condition can excessive gas and furnace temperatures be avoided.

Any boiler tube or side wall tube surface exposed to the direct rays of the fuel bed or flame absorbs heat by radiation and in a definite quantity, depending upon the temperature difference.

Assuming 80 per cent efficiency, approximately 42,000 B.t.u. have to be liberated per hour in the furnace per developed boiler horsepower. As 30 per cent of this, or 12,600 B.t.u. must be taken care of by radiant heat absorption, we can readily compute the limitation of a furnace in developed horsepower per square foot of black surface exposed to radiant heat in the furnace.

Since it is well established that each square foot of black surface, at least as far as the boiler is concerned, will absorb approximately 75,000 B.t.u. per hr., we get six developed horsepower per square foot of black surface as the maximum that can be expected from any boiler, in any furnace and with any method of firing. It is possible, with some high fusion ash coals, to go a little higher but, with a large number of coals where the radiant heat absorption must be more than 30 per cent, it will be less.

We can, therefore, set down as a third fundamental fact that six developed horsepower per square foot of black surface exposed in the furnace is a definite dead line that cannot be exceeded without furnace deterioration and slagging, regardless of the method of firing, unless the $CO_2$ is dropped and the furnace temperature lowered by air dilution.

### Adequate Radiant-Heat-Absorbing Surface Essential

Applying this to boilers generally, we find that, if the entire length of tubes is exposed and at least the two lower rows of tubes so as to form a complete black area, we can get approximately 200 per cent of rating. Some boilers fall short, others again permit of operation up to 300 per cent.

From this it is evident that a boiler say 13 tubes high and correspondingly wide is better for any type firing than one 16 to 18 tubes high and correspondingly narrow. For 200 per cent of rating a 500-hp. boiler must have at least 166 sq. ft. of black surface exposed which will, in turn, necessitate 10-ft. furnace width. When operating with 14 per cent $CO_2$, the two lower rows of tubes must do 30 to 40 per cent of the work. It is an established fact that the shallower, wider boiler has a greater overall officiency with the higher $CO_2$ than the narrower, higher boiler, due to the greater radiant heat absorption and lower temperature of the gases entering the boiler. It is the heating area exposed to the flame that counts, from the standpoints of both efficiency and rating.

Reasoning from the above, the use of the bridge wall is wrong, as it cuts down the radiant heat absorbing surface. Bridge walls have been omitted in many stoker installations of recent years, in full recognition of this fact. A dutch oven or arch effect over the flame or fuel bed is wrong where it shields the flame or fuel bed from the tubes, resulting in the building up of excessive temperatures in that portion of the furnace.

It follows, of course, that, where the developed boiler horsepower is in excess of six times the number of square feet exposed to the radiant heat, additional black surface must be provided in the furnace, usually in the form of watercooled side walls Watercooled walls are, however, not the object. It is not a question of cooling the walls but of the necessary black radiant heat absorbing surface to take care of 30 to 40 per cent of the heat input.

Our starting point in furnace design then, for any type of firing, is to provide adequate radiant heat absorbing surface for the rating desired and for the coal to be used, which, as seen, is limited with most boilers to 200 per cent, or with some to less, additional heat absorbing surface in the furnace being required above this limit.

### Pulverized Coal Furnaces

Next to be considered are the size and volume of the furnace, and we refer first to the pulverized coal furnace.

At the outset, it may be said that a given heat liberation per cubic foot per hour as a determining factor is without sense or meaning. A narrow type furnace may have a heat liberation of only 12,000 B.t.u. per cu. ft., yet suffer more deterioration than one of better proportions and with proper placement of the flame operated at 24,000 B.t.u. It is a question not of volume, per se but of effective volume and clearance between the flame and the confining walls of the furnace, floor and heating surface.

When a turbulent burner is used, in which all the air required for combustion enters with the coal in a thorough mixture, the flame is definite, sharply outlined, burning from the burner like a gas flame. It occupies a definite volume in the furnace. It can be mushroomed, shortened, narrowed or lengthened to suit the particular furnace.

Space occupied is small, as the average heat release within the flame volume is considerably in excess of 100,000 B.t.u. per cu. ft. per hr. In other words, as far as space actually required for combustion is concerned, one cubic foot per 100,000 B.t.u. heat release or one cubic foot per 2 1/3 developed boiler horsepower is all that is required. It is for this reason that pulverized coal can be burned successfully with such necessarily high heat release in the Scotch marine boiler.

Several other limiting factors must, however, be taken into consideration. Where we have a refractory furnace, clearance must be provided between the flame and the refractory to prevent gas erosion and direct contact between the walls and the molten ash in the flame; also clearance between the flame and tubes and between the flame and the deposit of ash below, for obvious reasons. This will, of course, add materially to the total furnace volume.

Mainly, however, consideration as to volume relates to the distribution of the radiant heat. The flame radiates heat in all directions equally but only from the top side directly to the tubes. In other words, only about one-third of the radiation is directly to the tubes, the other two-thirds going to the walls and floor.

As far as the top of the flame is concerned, it must have a reasonable clearance from the tubes so that the radiation will distribute over as much as possible of the

tube area. As radiant heat acts like light, the problem is the same as the placement of the flame best to illuminate the tube area. Getting the radiant heat, originally directed to the walls and floor, past the flame to the tubes is the major problem and the determining factor in the matter of clearance around the flame. If we have black surface walls and floor installed to absorb this heat, or an all-black furnace, it's only a matter of providing a nominal clearance, allowing heat liberation up to 50,000 B.t.u. per cu. ft. and even higher in the Scotch marine type furnace. If a slag tap furnace is used, little or no clearance need be provided between the flame and the bottom.

In an all-refractory furnace, however, provision must be made for the radiant heat to get back into the water by reflection and reradiation. Consider first the floor with its cover of ash subject to the radiation of the flame above. The flame itself is opaque to heat passage so we get a reverberatory effect between the bottom and the flame, a reflection and reradiation back and forth between the flame and the floor, building up the temperature on the floor below the flame to flame temperature, if the flame fills the entire furnace area above the furnace bottom so that no rays can get by to the boiler above.

If the furnace area is substantially larger than the flame, with a liberal clearance between the flame and the walls and the surface of the ash a substantial distance below the flame, the reflection and reradiation from the ash or floor will get past the flame. Radiant heat acts like light waves; the floor and walls like mirrors. Downward-directed rays hit the ash and may reverberate back and forth directly under the flame but, due to refraction and reflection, eventually get through the space around the flame. Radiance from the floor hits the walls at an angle and reflects to the tubes. In like manner, the radiant heat from the walls reaches the tubes.

Theoretically, the walls should be tilted inward at the bottom and the floor should be tilted at an angle with the walls so that the reflected rays, striking at an angle, will reach the tubes. All arches should be set at an angle, to direct the rays to the tubes or a reflecting wall surface.

As a fourth fundamental, then, furnace volume must be considered from the standpoint of proper areas and clearances to take care of the redirecting of the radiant heat to the heating surfaces and not from the standpoint of mere furnace volume.

### Flame Shape and Placement and Wall Disposition Are Important

Space requirements in a furnace are not a matter of cubic feet or specific distances, or even of specific clearances around the flame which can be set down in feet and inches as fixed quantities. That the radiant heat from every surface may get to the boiler without excessive reverberatory effect is the sole determining consideration. This involves shape and placement of the flame, as well as the shape and disposition of the walls and floor of the furnace, more than the actual volume. In an all refractory furnace it may allow a heat liberation of only 10,000 B.t.u. per cu. ft. or as high as 30,000, depending entirely upon the radiation provision factor, which in turn is a matter of shape, wall arrangement and flame placement as much as it is clearances and volume.

Naturally, this involves a large number of variables that cannot be given fixed values. Full appreciation of the fundamentals, experience and judgment are required for good designing, with margins of safety where there is any question whatsoever.

### Gas Flow and Air Supply

An important consideration entering into furnace design is the flow of the gases. Any stream lining, short circuiting or excessive velocities from burner to boiler pass must be avoided to eliminate the possibility of carrying away combustibles. Flow of the gas should be as uniform as possible to give a uniform time of retention in the furnace.

Generally speaking, it is preferable to maintain the flow in one direction without hairpin turns. Firing a bent-tube boiler from under the drum is more nearly right, if possible to set the boiler in that manner. Firing a horizontal-tube boiler from the low end is preferable in order to get the pass entrance at the end opposite the burner. This lessens the clearance between the flame and the tubes, for the products of combustion to return over the flame, which is necessary in the case of front pass opening. It gives better utilization of the rear end of the furnace. Radiant heat is also better distributed from the stretched out flame and there is no shielding of the flame proper by the return flow of gas.

In firing pulverized coal by injecting with the fuel only a part of the air required for combustion and adding the rest of the air in the furnace, other factors are introduced that must be considered in the design. Completion of combustion is, of course, delayed until a complete mixing with the additional air takes place, which increases the flame length and space occupied. Also mixing is a problem conditioned largely on the action of convection currents and it is difficult to get stream lines of fuel or concentrated coal-air mixtures coming in from one point to mix with air from some other point. There is no way to determine the furnace volume precisely, which accounts for the large furnaces that have been specified in many cases for this type of firing. The writer believes that the best method of burning pulverized coal is from a burner where all the air required for combustion, accurately proportioned, is thoroughly mixed with the fuel so that the flame is definite in size and proportions, minimum in length and volume. There can then be a definite, knowable starting point for determining the other factors entering into furnace design.

### Stoker-Fired Furnaces

It has been noted above that the requirement, as far as stoker or grate-fired furnaces are concerned, is the same with respect to the required radiant heat absorbing surfaces. It is now standard practice to expose the full length of the tubes to the fuel bed and to provide additional black surface in the furnace for operation materially above 200 per cent of rating. There can be no exception to this practice where high $CO_2$ is to be maintained, whether the boiler be large or small.

With a stoker or grate, the problem of radiant heat in the bottom of the furnace does not, of course, exist.

The fuel bed is the bottom of the furnace proper. The stoker and ash pit occupy the space required under the flame in a pulverized coal-fired furnace.

Radiant heating surface occupies the full area of the furnace, although the stoker itself may be, in many cases, shorter than the boiler. The problem of radiant heat dispersal is merely a matter of providing the required absorbing surface exposed to the fuel bed.

### Air and Space Above Fuel Bed

Several other problems enter in, however, which are often overlooked. In burning coal on a grate, whether it is stoker or hand-fired, consideration must be given to how and where the actual combustion takes place and the requirements for its proper completion.

Coal does not burn as coal. Before combustion takes place, the volatiles are driven off. These range from 20 to 50 per cent of the fuel value and appear above the fuel bed near the front end of the furnace. They must be burned in the space above the fuel bed. The remaining carbon residue in part burns on the grate to $CO_2$ but the larger percentage is merely gasified to CO.

Carbon burns to $CO_2$ in the lower two or three inches of the fuel bed. When the fuel bed is much thicker than this, the $CO_2$ passing through the incandescent carbon above, picks up additional carbon and appears above the fuel bed as CO. The moisture in the air and fuel also reacts with the carbon producing CO and H. Reaction in the fuel bed is a gas producer action. The coal is literally gasified, not burned. The burning takes place in the space above the fuel bed.

Combustion is a function of the furnace, the space above the fuel bed, not of the grate or stoker. The stoker feeds the coal and air and must be depended upon to maintain the right proportions. That is all the stoker can do. It is a coal-gasifying means with controllable coal and air supply, not a coal-burning means. The furnace is the burning means.

As will now be appreciated, only a small percentage of the air reacts with the fuel in the fuel bed, since the bulk of the air must pass through some portion of the grate as free air, to mix with and burn the gas above. It is the problem of the stoker designer to maintain his fuel and air ratio and the ratio of gasifying air to free air so as to get the desired proportion above the fuel bed where the combustion does take place.

It is the problem of the furnace designer to provide volume and distance of gas travel sufficient for the right mixing of the gas and air, so that complete combustion results. The distillates rise at the front end of the furnace, the CO and H are generated in the homogenous and active portions of the fuel bed and most of the free air comes through in the rear and along the sides. These elements must be brought together and be thoroughly mixed.

In some modern stoker installations, part of the air is added above the fire by a set of high-pressure air jets along the front wall, just above the fuel inlet, that tend to drive the volatiles back, producing a turbulence and mixing action in the furnace. Such an arrangement is effective and has been in use in the form of steam air jets to mitigate smoke conditions in low-set installations for some time.

If, however, accidental convection currents are depended upon, considerable height is required to get thorough mixing. Without turbulence, little or no mixing is possible in the first 6 to 7 ft. above the fuel bed, as tendency for the gas and air streams to converge toward each other is slight. Experiments conducted by the Bureau of Mines have demonstrated that, with high volatile coals, complete mixing is not effected in less than 15 ft. travel. Where this height is 15 ft. or more, as in the case of central station and better industrial installations, the desired results are obtained.

Unfortunately, smaller boilers cannot be economically set to any such height, hence a compromise is necessary. Where the operation is below 200 per cent of rating, less height is necessary, due to lower gas velocities in the furnace. A greater amount of excess air may be employed at peak ratings, to insure sufficient air mixture with the gases. Over-fire cross current air jets may be employed to produce turbulence.

No compromise is admissible, however, in the matter of getting the setting high enough to insure thorough mixing. Nine out of every ten boilers below 500 hp. have been set too low. Where operated at 14 per cent $CO_2$ with coals containing in excess of 20 per cent volatiles there is smoke, indicating the escape of unburned volatiles.

No boiler should be set less than 8 ft. from the fuel bed to tubes, even when some means of producing turbulence is provided. If no such means is provided, the setting must be substantially higher, if complete mixing is to take place, with the minimum amount of air allowable to get the best efficiency. Twelve feet should be taken as the minimum with high volatile coals.

Where premixed pulverized fuel and air burning is employed, or thorough mixing is obtained by cross furnace air jets above the fuel bed of the stoker, the required volume is determinable and not large in either case, as figured in heat release per cubic foot. Where the fuel air mixing is entirely dependent upon accidental convection currents in the furnace, whether it be pulverized fuel firing or stoker firing, the volume requirement is large, as the mixing effect is dependent upon distance of travel, time of retention in the furnace and many accidental and variable factors.

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Asbestos sold or used by producers in the United States in 1929 amounted to a total of 3155 t., valued at $351,004, according to figures compiled by the United States Bureau of Mines from individual reports furnished by producers. These figures represent 1983 t. of chrysotile, valued at $317,584 mined in Arizona and Vermont, and 1172 t. of amphibole, valued at $33,420, mined in Georgia, Maryland, Montana and North Carolina. As compared with 1928, figures for chrysotile showed an increase in quantity but a decrease in value, while amphibole showed increases in both quality and value.

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According to a recent despatch from Berlin, flower raising has become a side line of the business of generating electric power. The city of Berlin has built a number of hot-houses near its electric power plants and pumping stations. These hot-houses are heated with steam from the power houses and flowers are raised in them. Results have exceeded expectations, it is stated, because imports of flowers from Holland and Southern France have decreased considerably.

# Burning Waste Fuel with Underfeed Stokers

BARK, WOOD WASTE, COKE BREEZE AND OTHER FUELS CAN BE HANDLED EASILY ON UNDERFEED STOKERS. BY R. A. FORESMAN AND DONALD J. MOSSHART*

MANY PLANTS find themselves in possession of quantities of waste fuels, such as pulpwood bark, sawdust, scrap wood, domestic size coke, coke breeze and anthracite waste. Generally the available amount of such fuel is not sufficient to pay a good return on the investment in a separate boiler and furnace designed especially for its utilization. Such fuels can be burned quite efficiently and economically with an underfeed stoker.

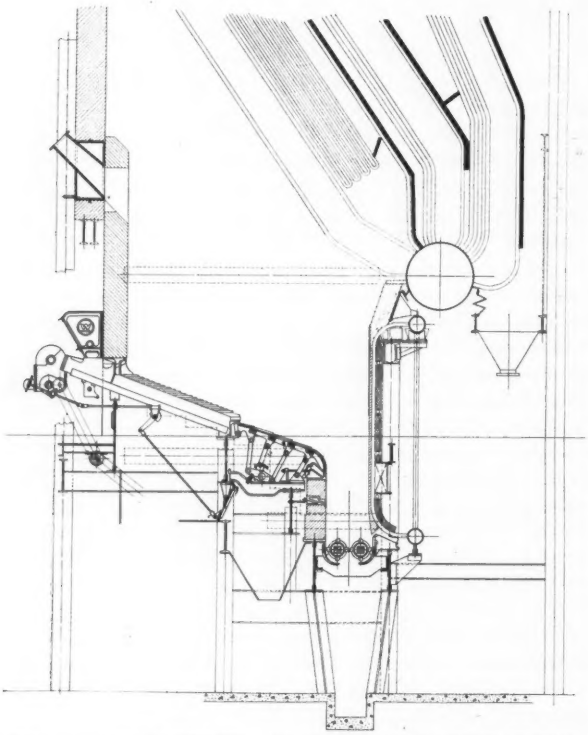

FIG. 1. ARRANGEMENT OF CHUTE FOR INTRODUCING FIBROUS FUEL INTO THE FURNACE

If the fuel is of a fibrous nature, liable to clog the rams, it can be burned by dropping it on top of the fuel bed, through chutes in the front wall. Such a scheme will work well with hogged wood refuse or similar material. Figure 1 shows such an installation at a new plant. In making such an application, the following should be observed:

The chutes in the front wall should center on equal portions of the stoker width. They should be located from 7 ft. to 10 ft. above the grate surface and should be spaced not more than 7 ft. apart. Such precautions are necessary to assure fairly even distribution of waste fuel over the stoker fire.

Provision should be made to admit the waste fuel into the furnace as nearly continuously as possible so that uniform combustion conditions can be maintained.

Blowing the fuel into the furnace with a current of air is unsatisfactory, unless the fuel is actually pulverized. Even small chips of wood will drop to the bottom of the furnace, leaving the conveying air current to pass upward from the chutes as useless excess air.

The better method of supplying the fuel is to have some sort of feeder or paddlewheel arrangement, which drops the fuel into the chute at a controllable rate; relying on gravity to feed the fuel through the chute. By maintaining proper draft conditions in the furnace, the amount of air infiltration through the open chute can be made negligible.

The chute should be made divergent, that is, it should increase in area as it approaches the furnace in order to prevent clogging. It is preferable to watercool the edges of the chutes next to the furnace. The amount of heat thus absorbed can be made so small that the cooling water can be discharged to waste without undue loss.

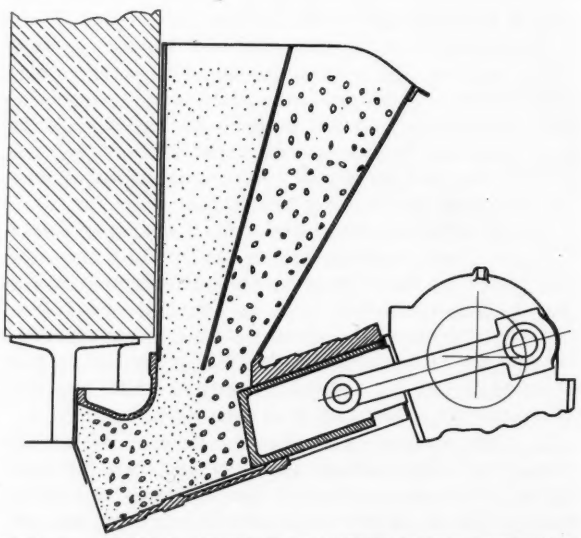

FIG. 2. SPECIAL HOPPER PARTITION FOR BURNING COKE AND COAL TOGETHER

Generally speaking, provision should be made for the injection of considerable quantities of free air over the fuel bed, under the control of the operator. This is particularly necessary if the fuel waste contains resin, oil, or similar substances.

If the waste fuel is granular or brittle in character, as coke breeze, or anthracite waste, it is burned to best advantage when mixed with the coal. Such mixtures are hard to make and maintain in the bunkers. Coke, particularly, has a pronounced tendency to separate from the coal, so that the stoker receives alternate batches of coal and coke from a bunker mixture.

*Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.

Figure 2 shows a mixing device which has been successfully used. In this device, the stoker ram feeds with each charge definite amounts each of coal and other fuel. Above the ram the hopper is divided into two compartments. The compartments are separated by a movable partition, the front compartment being supplied with coal, the rear one with other fuel. The position of the partition determines the relative proportions of coal and other fuel which will be fed in by the ram. By the time the retort mechanism has fed the fuel up into the fire, the two fuels are well mixed. The ram is always surrounded by coal, so that it is protected from the abrasive action of the other fuels.

The capacity of the unit will generally be reduced if waste fuel is mixed with the coal. By making the partition quickly adjustable, the peak capacity of the stoker can be retained. The waste fuel can be cut off and the stoker operated on coal alone during periods of heavy load.

# Automatic Boiler Plant Control

INCREASES CAPACITY, REDUCES OVERHEAD AND IMPROVES SERVICE.* BY E. G. BAILEY.

INCREASE OF efficiency results in lower fuel consumption per unit of output, hence in increased capacity and reduced overhead. Also less labor is needed for handling coal and ashes and, with automatic control, less for attendance on boiler operation. With conditions steadily maintained at their best, longer periods of safe, economical operation result, hence reduced outage and improved service.

Modern power plants are designed to operate as economically as is consistent with continuity of service and equipped to give maximum efficiency. But to realize on the investment required, equipment must be operated under conditions for which it was designed.

In other words, 1400-lb. boilers should work at 1400 lb.; 750-deg. turbines should have 750-deg. steam; furnaces intended for 20 per cent excess air should have that condition at all boiler outputs if economy and return on investment are to be obtained.

Expert operators have learned the right sequence of adjustments for fuel, air and feedwater as load varies in order to get best results but can make such adjustments only after changes in load have taken place. Automatic control must accomplish the same results as the most expert manual control but can detect changes and make adjustments more quickly as well as eliminating the human element of fallibility.

Primarily combustion control is to supply fuel and air in proportion to steam demand, changing the rates of supply as steam demand varies, and steam pressure changes at some selected point in the system. In order to eliminate time lag, it is desirable to design control equipment so that it will operate according to rate of change of pressure rather than to deviation of pressure from normal standard, thus stopping a change in pressure as quickly as possible. At the same time, as soon as the tendency to change from normal pressure is overcome and started toward the standard, change in fuel and air supply should be modified to avoid passing normal pressure and resultant "hunting" of the system.

Steam pressure must be maintained but combustion efficiency requires use of minimum excess air and high furnace temperature. The second problem of control is to accomplish this. Parallel control of fuel and air without readjustment will fail of the desired result because of varying factors in air and full supply such as atmospheric conditions, moisture and fineness of fuel and height in the bin. For stokers, volume of coal may bear fairly close relation to stoker speed but variation of quality of coal makes constant ratio of weight of air to stoker speed incorrect for best combustion.

Experience has shown that the feasible guide to obtain desired relation between fuel and air is the percentage of excess air that will maintain total losses due to excess air and unburned fuel at a minimum. Or, if this results in excess refractory deterioration, the percentage excess air to give most economical overall results.

Relation of steam flow from the boiler to flow of combustion air is a correct indication of the percentage of excess air, as the former is a gage of rate of heat development in the furnace, while the latter measures the rate of air supply to develop that heat.

Automatic control may be adjusted to vary the percentage of excess air with boiler output. It may be desirable to use 50 per cent excess for stokers at low and 20 per cent at high output, while for pulverized coal, 30 per cent excess may be desirable to eliminate smoke at low and 15 per cent at normal output to and up to 35 per cent at high output to hold down furnace temperature. By keeping air supply at a minimum, not only is fuel conserved but power for auxiliaries is saved.

Safety features are important, such as travel limits, interlocks between fuel and air supply to prevent excess fuel at high air limit and lack of air at low fuel limit.

Feedwater control, under present conditions where the drums have only 15 to 20 per cent of the water storage, must be sensitive and positive. If feed is shut off at maximum output, the drums would be dry in less than two minutes. This is taken care of by the three-element regulator which functions according to steam flow from the boiler, and water level in the boiler drums, the water flow being controlled to correspond with rate of steaming and water level. Constant weight of water is maintained in the boiler but water level rises at high output and sinks at low output because of swelling and shrinkage of water in the boiler due to the amount of steam bubbles formed below the water surface.

With present effectiveness of operation and increased efficiency, omission of automatic control must be justified by an exceptionally high standard of manual control.

*From a paper at the World Power Conference, Berlin, June, 1930.

**President, Fuller Lehigh Co.

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INTRODUCTION of steel switchboards has reduced installation costs from 50 to 75 per cent. The weight is reduced to about one-sixth that of slate panels and they are not subject to fracture.

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STEAM TURBINES have an auxiliary or overload valve which opens to admit live steam to the low-pressure stages during overloads.

# SCREEN HOUSE COSTS MUST BE LOWERED

By A. Streiff

Allied Engineers, Inc.
Jackson, Mich.

IMPROVED DESIGNS INCREASE CAPACITY AND SCREENING EFFICIENCY. ANOTHER DESIGN WHERE THE PUMP PRECEDES THE SCREEN SHOWED AN ESTIMATED SAVING OF $40,000 IN FIRST COST.

MODERN LARGE STEAM PLANTS require large quantities of cooling water. Some 600 t. of water are required for every ton of coal burned. For a large plant this becomes equivalent to the flow of a river having a drainage area of more than 1000 sq. mi. The problem of procuring and screening such quantities of water attains important dimensions. The power required should be a minimum and the water should be clean. Cleaning of condensers, in many steam stations regarded as part of the daily routine, often can be ascribed to defective screen house arrangement. Figure 1 shows a view of the condenser tubes of a 20,000-kw. turbine after removal of the cover plate. This occurred in a new installation and is due to insufficient cleaning action of the usual type of revolving screen.

FIG. 1. DEBRIS ON CONDENSER TUBE SHEET DUE TO INSUFFICIENT SCREENING

Often the location of the intake contributes difficulties resulting from detritus. This should be governed by the rules of irrigation engineering. Neglecting these leads to interruptions of service. In a recent $2,000,000 steam station, the water was taken from a shallow, small stream. Besides locating the intake on the convex bank where all trash carried by the stream is deposited, the sill of the racks was placed at an elevation much lower than the river bed, necessitating a dredged hole in front of it. This was promptly filled with gravel at every high water, the gravel entering the boot and caused breakage of the revolving screens and filled up the pressure ducts.

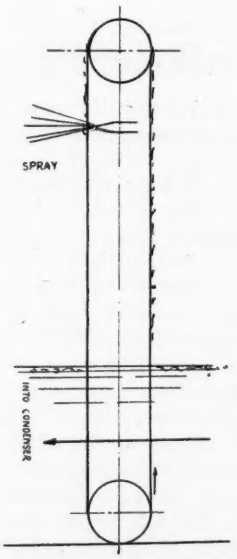



FIG. 2. IF THE SCREEN IS NOT THOROUGHLY WASHED, DEBRIS PASSES OVER IT AND INTO THE CONDENSER WITH THIS ARRANGEMENT

It is not possible to give a few simple rules for the proper location of intakes. In irrigation practice, the downstream end of the convex bank where it joins the concave shore line, is favored and a reverse intake provided but this does not apply to all cases.

Deep intakes in a shallow stream should not be expected to keep free from deposits. A high sill, extended sufficiently far downstream, providing for ample rack area but at no greater depth than normally exists in the river, will be more practical. Where the stream is exceedingly shallow, a weir should be built to give greater depth but at the same time a decantation basin should be installed. Hydroelectric practice, especially for high heads requires clear water; hence the arrangements or devices to procure it are highly developed. In a recent large hydro station in Southern Tyrol, a special cleaning plant is provided to eliminate sand, gravel and trash,

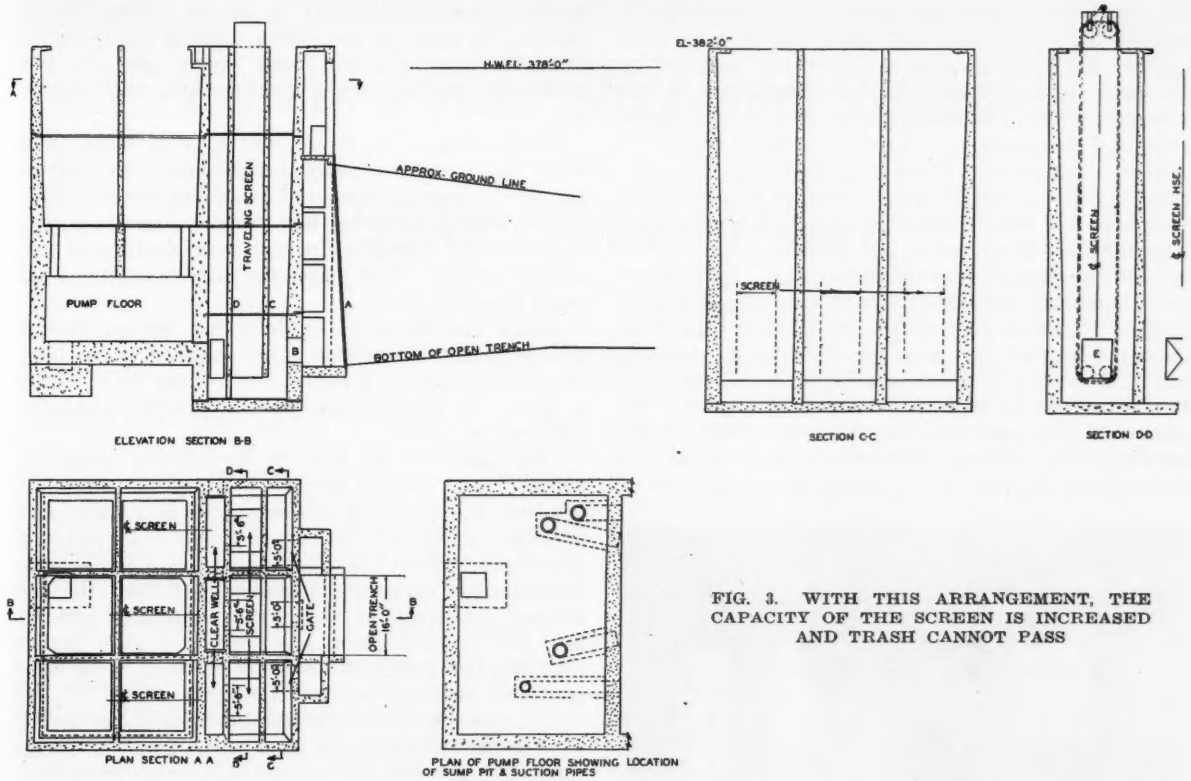


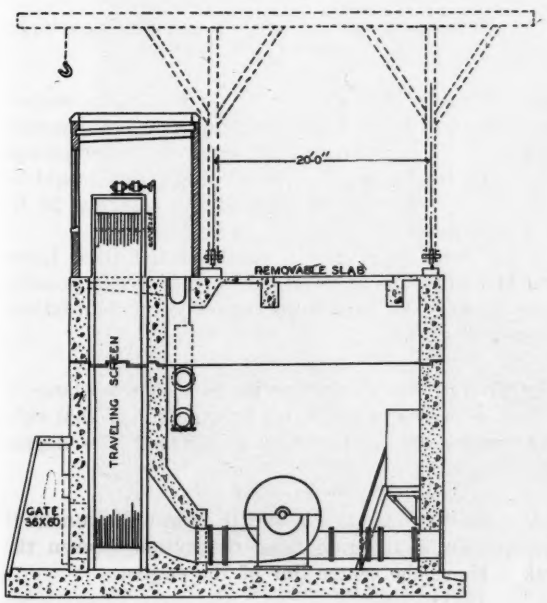

FIG. 3. WITH THIS ARRANGEMENT, THE CAPACITY OF THE SCREEN IS INCREASED AND TRASH CANNOT PASS

the discharge quantity thus cleaned being 3000 c.f.s. The same principles can profitably be applied to the water supply of large steam stations.

### Condenser Outage Should Be Reduced

Outage of large units on account of condenser cleaning should be minimized. Condensers should need only occasional cleaning. The Prime Movers Committee report of the N.E.L.A. for 1929 gives as the average frequency of cleaning two-pass condensers 29 times per year or once in 12.5 days. Five of the 26 condensers reported on required cleaning more than 50 times a year or about once a week. Assuredly these conditions are entirely unwarranted. Water supply pipes are cleaned only occasionally and in numerous instances the supply is taken from the same rivers serving as a source of cooling water.

By better screen house design, frequent condenser cleaning can be avoided. For this purpose, the screen design can be improved. The present revolving screens



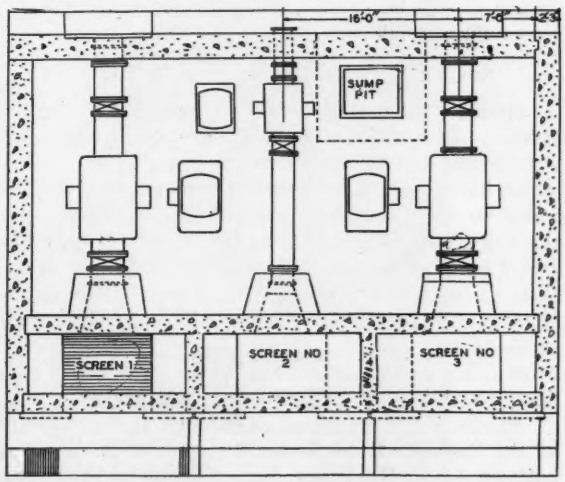




FIG. 4. THIS ARRANGEMENT CAN BE USED WHEN THE WATER CARRIES LITTLE SILT

are not always entirely satisfactory. The water has to traverse the screen twice and should the trash accumulated on the upstream face be imperfectly removed by the spray nozzles, it will then move downward on the downstream side, will be floated off into the circulating water and accumulate in the condenser as in Fig. 2. To eliminate this defect, Allied Engineers, Inc., has provided a different screen arrangement, as shown in Fig. 3, for the Ohio River Station* at Evansville, Ind. Water from the Ohio River enters the racks at A, and passes through the gates B into the screen pits. Each screen pit is separated into three parts by two walls C and D. Section CC shows that wall C terminates 4 ft. 6 in. above the floor of the screen pit, allowing the water to enter the screen compartment through this aperture 4 ft. 6 in. high by 14 ft. 6 in. wide. The screens completely fill the space between the walls C and D, and are a continuous chain of wire baskets rotating over four horizontal shafts and sprocket wheels as indicated in

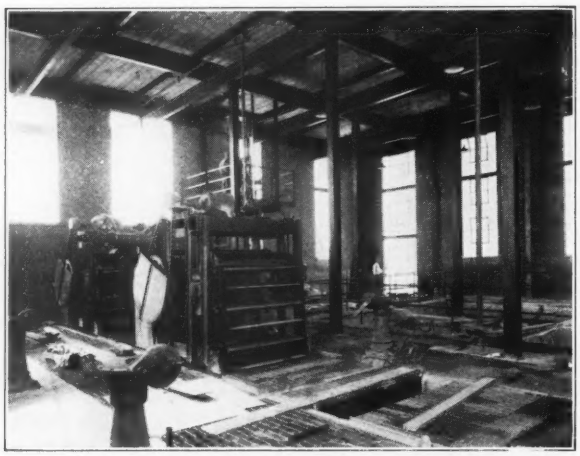


FIG. 5. TWO OF THE SCREENS AT THE OHIO RIVER STATION

Section DD. Water enters the screen from both sides and the bottom. This has the added advantage that the width of the screen is much smaller than usual, here only 6 ft. 4½ in. overall, while the total screen area is larger than usual.

### Screen House Costs Should Be Reduced

Hydraulic losses through the screen are therefore smaller. In addition, the trash accumulates only on the outside and insufficient cleaning cannot cause the trash which has accumulated on the screen to enter the clean water on the downstream side. The clean water enters the third compartment through aperture E of Section DD, Fig. 3. The first and third compartments are settling basins for mud and can be cleaned out by an electrically operated ⅜-yd. clamshell bucket. The suction pipes of the circulating pumps draw water from the third compartment, as shown by the plan of the pump floor, which contains water freed from trash.

Figure 4 is a cross section through the screen house of the Saginaw River Steam Plant, also designed and built by Allied Engineers, Inc. This plant has a capacity of 146,000 kw. The same screen arrangement is used but, as the river carries only a small amount of silt, no special cleanout apartment is needed. Sand has no tendency to enter, as the depth of silt is not below the natural channel depth. Trash cannot pass the new screens but remains on the upstream side until cleaned off.

Plants located on rivers with a large variation in water level require costly screenhouse constructions. The foundations must be well below low water and the screens must reach above high water. The pump room must be low enough to permit safe starting of centrifugal pumps. This makes for deep foundations and pump room.

Much can be saved by following sewage disposal practice. Here the sewage is not screened at low levels but first pumped to a higher level where the screening is done. In this manner, much expensive foundation work can be saved.

The same can be done in screenhouse design for power plants. Instead of first screening the water at a low level, the raw water can be pumped to a higher level by means of vertical shaft screw pumps and screened at this higher level. The screw pump has a much better characteristic curve for variable head than the centrifugal, inasmuch as the power diminishes with the head and does not stay nearly constant or even increase with decreasing head, as in the centrifugal. Trash which passes the rackbars will pass the screw pump.

An example of such an installation is shown in Fig. 6. The variation in water level is here 20 ft.; the screw pump lifts the water to approximately high water level,

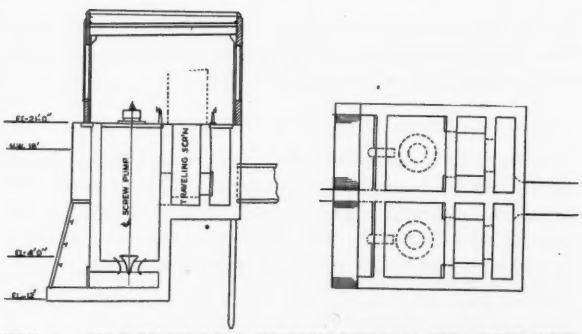



FIG. 6. AN ECONOMICAL DESIGN WHERE THE LOW LIFT PUMP PRECEDES THE SCREEN

whence it flows through the 6-ft. pipe to the station located 900 ft. away. The circulating pumps are merely idling at low water and at high water the screw pumps are idling. In this case, the circulating pumps could be eliminated by introducing a standpipe reaching 20 ft. above high water.

A similar project for a plant on the Ohio River where the variation in level is 70 ft., showed a possible saving of $40,000 by elimination of deep foundations and long screens.

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In English units, the specific heat of a substance is the heat added to or given up by a pound of that substance when the temperature is changed one degree Fahrenheit.

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A horizontal engine is said to be running under if the crankpin is receding from the cylinder when the crank is above the center line of the engine.

*For a description of this station, see page 1148 of the Nov, 1, 1929, issue.

# *Diesel Power Replaces Steam at Public Utility Plant*

LOW REPAIR COST CHARACTERIZES OPERATION OF CONSOLIDATED PUBLIC UTILITY CO.'S PLANT AT WESTMINSTER, MARYLAND

POWER FOR WESTMINSTER, Maryland, was furnished originally by a small steam plant built in 1883. Ten years later, a competing company built another steam plant and paralleled the electric lines. Gas and water were served by two other resident independent companies. All four companies were consolidated in 1908 under their present name.

### STEAM POWER DISPLACED BY DIESEL POWER

Addition to the original power house was made in 1925 when the first two 400-hp. Diesel engines were added to supplement the work of the steam units. This addition is 40 ft. wide by 80 ft. long. The units were put in operation in February, 1925, and a third Diesel of 500 hp. in July, 1926. The last Diesel, which is of 660 hp., started operation on May 14, 1930, and, with its installation, the steam plant was abandoned although the equipment still stands. All four of the present power units are De La Vergne Diesel engines.

Diesel engine-generator units 1 and 2 are identical, both having 400-hp., 4-cylinder engines direct connected to 300-kw. General Electric alternators. No. 3 unit has a 500-hp., 5-cylinder engine direct connected to a 350-kw. alternator. No. 4 unit has a 660-hp., 6-cylinder engine, direct connected to a 500-kw. alternator. All of the engines are of the 4-cycle, solid-injection type running at 225 r.p.m. and all of the alternators are of the 60-cycle, 3-phase type generating electricity at 2300 v. and operating at 0.8 p.f.

Separate excitation is provided by duplicate General

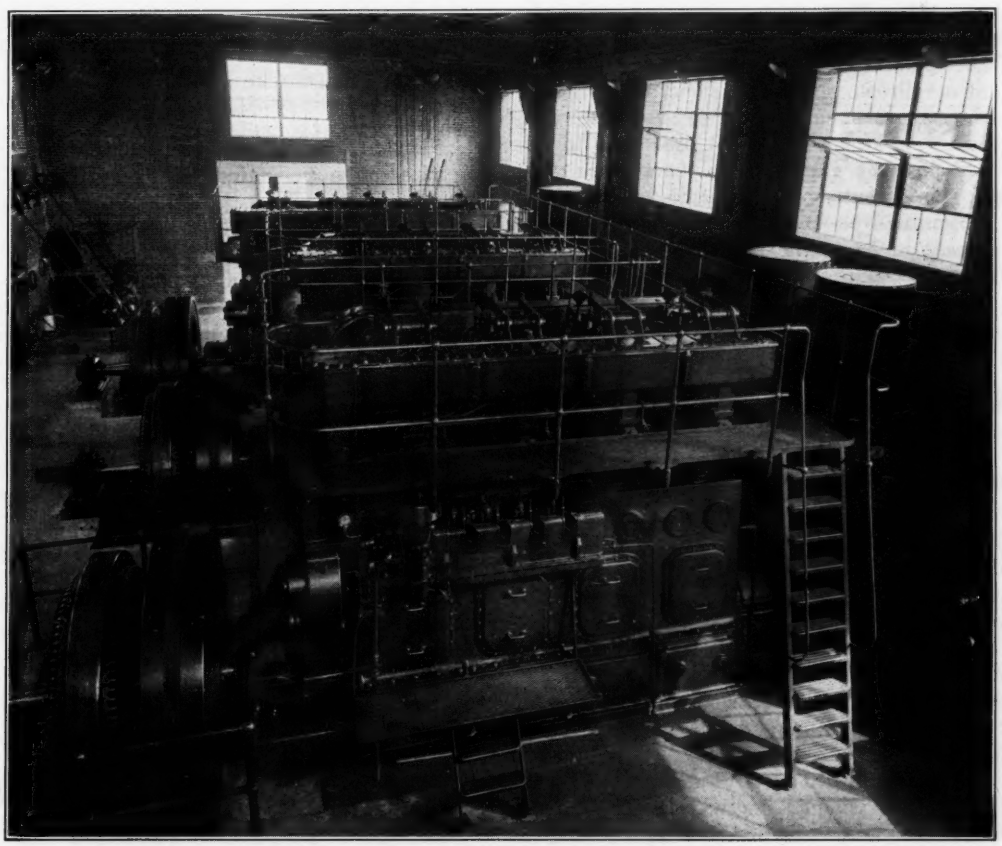

FIG. 1. FIRST THREE DE LA VERGNE DIESEL UNITS TO WHICH A FOURTH HAS BEEN ADDED

Electric 30-kw., direct-current, compound-wound motor-generator sets, 125 v. operating at 1800 r.p.m. No. 1 engine also has an exciter that may be quickly belted to it if the motor-generator sets are inoperative.

Availability of a large quantity of soft water avoids the necessity of softening or cooling equipment. Cooling water is secured directly from the city main and returned to it again. Where no treatment for softening is carried on, it is customary to keep the temperature of the cooling water down by using a larger quantity than would otherwise be necessary so as to reduce to a minimum the possibility of deposition of salts. This easily

FIG. 2. SECTIONAL SWITCHBOARD IS INSTALLED IN A BAY AT END OF ENGINE ROOM

can be done at the Westminster plant hence the discharge temperature is kept below 105 deg. in this plant.

Two 50,000-gal. steel tanks, located above the ground alongside of a railroad siding and about 1000 ft. from the engine house, provide ample fuel storage. No warming is necessary to keep the fuel oil used fluid in this location. Oil flows by gravity from the storage tanks to a 160-gal. supplementary tank which is located in the basement adjoining the engine room. Deming hand pumps are used to pump the fuel to the daily-supply tanks which are located on the wall as shown in Fig. 1. All fuel oil is measured by passing through National Meter Co. meters.

Being located in the country where the air is comparatively free from dust, no dust removal device was found necessary in this plant. Air, for the engines, is brought in through a duct which opens above the roof.

### Newest Installation Uses Pressure Lubrication

Each of the first three engines is supplied with lubricating oil from an individual 160-gal. supply tank which is located in the roof trusses at a height sufficient to produce a pressure of 3 lb. The No. 4 engine has a 160-gal. pressure tank for this purpose. This is attached to the wall and gives a pressure of from 12 to 15 lb. All lubricant passes through a De La Vergne oil filter as it enters the engine and is gathered in a settling pit alongside of the engine after it has been drained from the engine.

Starting air is provided by a duplicate set of 3 by 3½-in. Gardner air compressors which are belted to 3-hp. General Electric induction motors running at 1730 r.p.m. The starting air pressure is held at from 200 to 212 lb. Manifold and exhaust pipes are water jacketed to the floor line to cool the exhaust gases. Brown electric pyrometers are used for indicating the exhaust temperatures of the various engine cylinders.

Alternating current is distributed from the station at 2500 v. The switchboard, supplied by the General Electric Co., is located in a bay, off the engine room. It is made up of sections bolted together as shown in Fig. 2, each generator unit having its own switchboard section. A synchroscope attached to a swinging panel at the left of the board serves to synchronize the generators coming into operation. A typical summer load curve is shown in Fig. 3.

### Low Repair Record

Although repair requirements have been exceptionally light, a fine repair shop equipped with lathe, drill press, radial drill and planer machine tools and oxyacetylene welding equipment, located in a separate building adjacent to the engine room, is available. This shop is provided for all of the utility requirements. It is used mostly for water and gas line work.

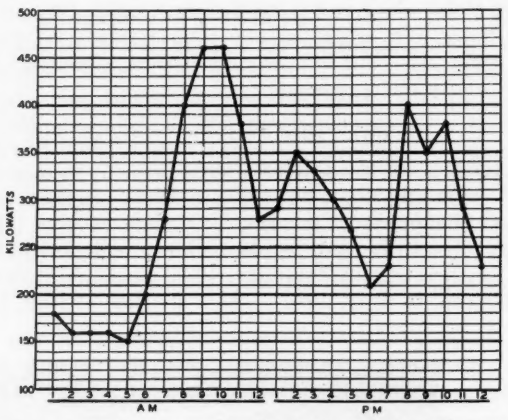


FIG. 3. TYPICAL SUMMER LOAD INDICATES RAPID FLUCTUATIONS CARRIED BY THE POWER UNITS

Since the installation of the several engines, the only repair work required was replacement of two liners in engine No. 1 due to inattention to the lubrication system and the loosing and dropping of a set screw which destroyed a sprocket wheel, broke a rocker arm bracket and threw the engine out of time. A Yale hand-operated crane shown in Fig. 1 is provided for pulling the pistons and other inspection work. This crane is provided with one 1½-t. and one 5-t. chain operated spur gear block.

Due to the watchful care of F. A. Myers, the general manager of the company, who has had supervisory charge of the plant since it was built and to the able aid given him by his operating engineers, it has been felt that an elaborate record system was not needed. Hourly readings are made, however, of the kilowatts generated and monthly readings are made of the fuel and electric meters.

Yearly records show the following low rate of fuel consumption:

| Year | Fuel, gal. | Kw-hr. generated | Kw-hr. per gal. |
|---|---|---|---|
| 1927 | 252,063 | 2,226,534 | 8.8 |
| 1928 | 195,905 | 1,893,130 | 9.7 |
| 1929 | 206,979 | 2,034,830 | 9.85 |

# TESTING FOR TROUBLE *and* LOCATING FAULTS *in* ELECTRICAL EQUIPMENT

*Testing insulation resistance by means of the Megger*
*Periodic inspection to anticipate grounds, shorts and opens, important part of plant routine*

By Marin Phillips
Electrical Superintendent
International Paper Co.

INSULATION RESISTANCE holds the same relation in an electrical conductor to the flow of electrical energy through it, as the walls of a pipe do to the flow of liquids through it. A leak in this wall will cause a loss of the medium being conveyed, whereas a large leak may stop the flow altogether. The same holds true in an electrical conductor. Small leaks in the insulation become worse, until they develop into a short-circuit, thereby interrupting the flow of current completely.

Much has been learned about insulation resistance during recent years and a number of instruments have been developed for measuring this resistance.

Until these instruments reading directly in ohms were developed, insulation resistance testing was a job for the trained electrician, but now this has been simplified until anyone around the plant can make the test.

Among the most useful of these instruments is the "Megger" which has practically replaced the old magneto test set which generated an alternating current.

A high-resistance magneto will ring through a comparatively high insulation resistance, thereby giving misleading results by indicating grounds or short-circuits when the wiring is in good condition. Also, when the magneto is used to test a long cable or a large machine, it may ring the bell when the insulation is in good condition, due to the equipment acting as a condenser, being made so by the magneto's current charging it first in one direction and then in the other. Another misleading result may be obtained with the magneto when testing a circuit of high inductance. This may prevent sufficient current flowing through it to ring the bell, thereby indicating an open-circuit.

The best insurance that a plant can have against production interruption is a well insulated electrical system, which includes the generators, transformers if an a.c. system, switchboard distribution wiring, control equipment and motors. Systematic insulation resistance testing of this equipment is now recognized as an indispensable part of plant maintenance.

### Two Main Types of Tests

It is necessary to make two kinds of tests on an electrical system. First, the testing for weak insulation before trouble occurs and second, testing to locate the fault when trouble develops, which may be a ground, short-circuit or open-circuit. The more attention given to the first test the less will be required for the second.

The greatest enemy of the electrical system is accidental grounding; that is, some part of the current carrying members coming in contact with foreign objects,

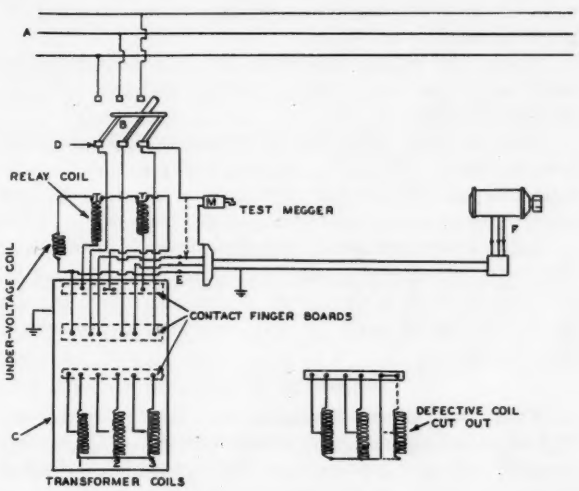


FIG. 1. WIRING DIAGRAM OF MOTOR CIRCUIT SHOWING APPLICATION OF "MEGGER" TEST
FI. 2. DIAGRAM SHOWING ELIMINATION OF DEFECTIVE COIL

such as water pipes, steel work of the building, or the conduit pipe that the wires are run in, due to the insulation weakening through age, absorbing moisture, or damaged during installation.

Motors and control equipment require periodic inspection and renewals of brushes, worn bearings, burned contacts, etc. The frequency of inspections depend on the severity of the operating conditions. Usually once a month will be sufficient. Each plant should have a "megger," to be carried by the maintenance crew, when making these monthly inspections.

When an inspection is completed, it takes only a few minutes to make an insulation resistance test on the equipment. When this practice is followed, severe interruptions of power will be practically eliminated.

Referring to Fig. 1, we have the main feeder A, safety switch B for disconnecting motor starter C from the feeder. The wiring, we will say, is in conduit from this starter to the motor.

To test the insulation resistance, have the switch B open, so that its lower terminal D will be dead. One wire from the test set M is connected to one of these terminals, preferably by means of spring test clips that will snap on to the terminal, or the bolt used for its connection. The other wire from the test set is attached to some grounded metal object, after cleaning a bright surface to insure a good contact. The handle of the test instrument is now turned and the reading taken off the scale indicating the circuit's insulation resistance to ground.

The value of this resistance reading will depend on the condition of the equipment, such as deterioration of the insulation, dirt, oil, carbon or copper dust, on contact finger boards in starter, and on d.c. machines, commutators and brush-holders. Much the same trouble will be evident on a.c. machines also.

Equipment when new, or old equipment in good condition, will show a reading as high as 100,000,000 ohms, one hundred megohms. But equipment can be considered in good condition at five megohms. Below this value it requires watching, while, at one megohm, it needs immediate attention.

These low values are given for low-voltage equipment in general use. Higher voltage requires a higher insulation value.

Now, to make an insulation resistance test, place the starting box handle in the starting position, thereby putting the whole electrical circuit in a position to test everything at once.

Suppose we now get a reading of, say 750,000 ohms. This will indicate that the insulation of some part of the circuit is in a dangerous condition. To find just where the weak spot is will require a process of elimination.

### Details of Testing

First, we might eliminate the auto-transformers. This is done by placing the starter handle in the starting position and taking a reading. If a ground is indicated in this position and doesn't show up when the handle is in the running or off position, the trouble is in the transformer coils.

If a ground is found to exist in the auto-transformer, the common connections, 1, 2 and 3, Fig. 1, will have to be opened one at a time until the faulty one is located. If the starting box has three transformer coils and one fails, it may be cut out of service and the other two used as a temporary repair as shown in Fig. 2.

Next assume that the starter handle is in the off position and the test reading is low. This means that the trouble is either in the line side of the starter or in the switch. In order to locate it, disconnect the line leads from the bottom of the switch at terminals D. Then if the low resistance is still shown up by the test, the trouble is in the switch.

If the switch is of the safety type, the trouble will be either in the cross-bar insulation, or the heads of the screws in back of the slate that fastens the live parts on to it. This often happens due to the sealing wax used for insulating the screw heads working out, allowing moisture and rust to form a low resistance path to ground.

In case the preceding test shows the switch to have a high value of insulation resistance, it indicates that the trouble is in the line side of the starter, which is due to one of the following causes: copper dust, dirt, carbon, etc., collected on the contact finger-board, which can usually be cleared by cleaning. Or one of the relay coils may be grounded. Then, too, the contact finger may be clamped on to a metal bar whose insulation may have become weakened. Such minor troubles as these can often be cleared up with little work by testing and locating them before greater trouble develops.

Now, suppose that the test set indicates normal resistance, that is a safe value, when the starter handle is in the off position, further assuming that we have eliminated the auto-transformer coils and that a ground is indicated with the starter in both the starting and running position. This indicates that the trouble is either in the motor side of the starter, the wiring to the motor, or the motor itself.

To run down the trouble further, disconnect the motor wiring at the terminals E and test again. If the insulation resistance is still low, the trouble is in the starter, most likely in the under-voltage release coil or trip circuit, or as mentioned before, copper dust, dirt, etc., on the finger board. First wipe the boards and contacts clean and test again. If this does not remove the trouble, inspect the under-voltage release coil and relay tripping contacts.

Sometimes a test will indicate a low-resistance ground on the first test that will clear up when the oil pan is lowered, due to water being in the oil.

If the low-resistance reading disappeared when the motor wiring was disconnected at terminals E, it indicates that the trouble is either in the motor wiring or the motor itself.

To trace out further the source of trouble, move the test set lead from the switch to the motor wiring terminals at E, as shown by the dotted line. Next disconnect the wiring at the motor terminals F and test again. Then if the low resistance is still present, it indicates that the trouble is in the motor wiring between the starter and motor, which more than likely means that new wire will have to be pulled into the conduit.

If the last test indicates a safe value, the trouble has been traced to the motor itself. If it is a d.c. machine, the trouble may be cleared by cleaning the brush-holders of all deposits of oil, carbon and copper dust, dirt, etc. If this fails to clear the trouble, some part of the windings has either absorbed moisture, which can be driven off by baking in an oven, or supplying artificial heat if the motor is too large for an oven. A great many motor re-windings can be prevented if they are caught and dried out before they breakdown.

Often a ground in an a.c. motor will develop due to worn bearings, allowing the rotor to rub on the stator laminations, displacing them enough to cut through the coil's insulation. To avoid delays and expense of this nature, gage the clearance between rotor and stator on the monthly control equipment inspections. In this way, worn bearings can be detected and changed before trouble occurs.

With a regular system of insulation resistance test-

ing, along with the inspection work, low-resistance in the motors, control and most of the switches and wiring can be caught before any serious trouble arises.

The tests described so far do not indicate the condition of the insulation between wires that guard against short-circuits; but this value is usually as good or better than the resistance to ground, so that the ground test gives a very reliable indication of the condition of the insulation between wires. Neither have these tests indicated the condition of the main feeder, the top of line switch or the wiring between this switch and the main feeder.

At regular intervals, the main feeders should be killed and their insulation tested to ground and between wires, when all of the line switches for the control equipment are open. If any main feeders are found with a low-resistance reading, each line switch will have to be disconnected until it is proved whether the trouble is in the main feeder or the top of the line switch. Then, too, it might be in the wiring between the switch and main feeder.

When starting to locate trouble on a main feeder, look over the wiring between it and the line switch. If any of the connections are run through conduit, these should be suspected first. If one should be buried in a concrete floor, this one would be the first one to eliminate, then the next worst looking one and so on.

In running down trouble in main feeders, a blueprint showing all connections taken off it is a great asset in locating the trouble.

The insulation resistance of main feeders should be kept in better condition than any of the small branch circuits, or control equipment, as a tie-up on a main feeder may affect a large portion of the plant.

### Troubles in Control Equipment

The troubles that are the hardest to find are those that develop in complicated control equipment, requiring a multiplicity of wiring. Here, again, the locating of trouble will almost be a hopeless task unless a blueprint is handy, showing all connections. If the connections are tagged, or made with wires of different colors, it will simplify the task considerably.

A short-circuit in the starter will be easy to find, as it will burn the insulation on the wiring or contact finger board so badly that it will be visible; but where the short-circuit develops between wires in a conduit pipe, it will not be visible, in which case it will be necessary to test for it. Usually the ground test already described will indicate that something is wrong with the wiring.

To test for a short-circuit, the motor wiring would be disconnected at points E and F, Fig. 1. This will leave the condition shown in Fig. 3; that is, the ends of the wires are separated at one end of the pipe and the test meter leads applied to the wiring at the other end.

To make the test, one lead from the test meter is applied to one wire, say No. 3. The other lead is connected to wire No. 2, and a reading taken, then to No. 1 and another reading taken. A short circuit will be evident if the meter reads zero.

To test for an open circuit, after the ground and short-circuit test has been made and the wires found to be free from either the wires can be connected together at the opposite end of the conduit from the test meter, as in Fig. 4. Then repeat the short-circuit test. If there is a break or open circuit in one of the wires, the test meter will fail to read zero resistance between the broken one and the other two.

The "megger" testing instrument is so vital a piece of equipment that no plant should be without one. When once in use, it indicates impending trouble far enough in advance that steps can be taken to eliminate it without waiting for the failure to occur, with its subsequent delay in production and expensive repairs.

A flashover on a brush-holder can often be prevented by a few minutes' cleaning, when the instrument shows a low-resistance reading. One company was having considerable delays where conduits for the motor circuits were buried in the floor, due to the pipe rusting away, allowing water to enter. After the megger test system was instituted, it completely eliminated these delays.

An insulation test on new equipment, wiring, etc., is

FIG. 3
TESTING WIRING FOR SHORT CIRCUIT

FIG. 4
TESTING WIRING FOR OPEN CIRCUIT

FIG. 3. TESTING FOR SHORT CIRCUIT
FIG. 4. TESTING WIRING FOR OPEN CIRCUITS

invaluable in insuring its condition being up to standard before applying power to it. It is not a very pleasant thing to throw in a switch on a short circuit, as has been done where the testing of the equipment was neglected before throwing in the switch.

He who wants unfailing power service will come nearer getting it through a systematic use of the megger testing set than by any other means.

Although a reference has been made to a.c. equipment throughout this article, the testing of d.c. equipment is much the same; that is, test and eliminate part of the circuit until the trouble is located.

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Brown coal is the name applied to certain low grade, high moisture coals found in some countries. It differs considerably from our American lignite. It has not metamorphosed as much as lignite. German brown coal runs in round numbers about half the heating value of our coal and varies from 40 to 60 per cent inherent moisture.

American lignites run from 30 to 35 per cent inherent moisture and must be mined by blasting like bituminous. German brown coal is soft, so soft in places after the overburden is removed a spade can be thrust into it. Exposed to the sun its woody structure is brought out and the annual layers of wood can be separated from one another. It will curl up like chips. Australian brown coal is even worse, a typical sample running 60 per cent moisture and showing a heating value of about 3000 B.t.u.

# Electricity---What It Is and How It Acts

PART XLII. MAGNETISM. HISTORICAL CONSIDERATIONS. FUNDAMENTAL MAGNETIC PHENOMENA. BY A. W. KRAMER.

ONE OF THE INEVITABLE accompaniments of electricity in motion, as we have seen, is a magnetic field. Every electric current is closely linked with a magnetic field and every magnetic field is linked with an electric current; one, it seems, cannot exist without the other. It is this inevitable inter-linkage of the magnetic field with the electric current that makes possible all present day electro-magnetic machinery from a simple electric bell to the largest electric generator.

This relation between electricity (electrons) and magnetism applies only to electrons in motion. Electricity at rest, as in a charged condenser, is not accompanied by magnetic phenomena of any kind; it is only when the electricity stored in a condenser begins to

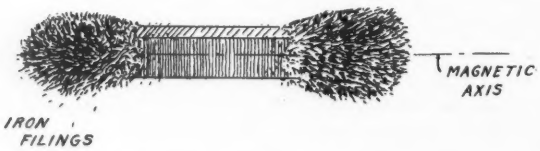


FIG. 1. A BAR MAGNET WHICH HAS BEEN DIPPED INTO A MASS OF IRON FILINGS. NEARLY ALL OF THE FILINGS CONCENTRATE AT THE POLES

move that the magnetic field makes its appearance.[1] An electric charge at rest has an electrostatic field but not a magnetic field.

This intimate relation between the electron in motion and the magnetic field leads us naturally, to a consideration of the nature of the permanent magnet as exemplified by the magnetic compass, the horseshoe magnet, and the natural magnet, lodestone or magnetite. Magnetism, as exhibited by the permanent magnet, has long been a mystery—more so, perhaps, than even electricity itself, for the compass needle by its peculiar ability to guide a ship across trackless oceans carried with it a power that, to more primitive minds, could be attributed only to some superhuman agency. Moreover, the permanent magnet in the form of lodestone was generally known long before the science of electricity was developed and because of the then limited state of scientific knowledge, its action, naturally was more of a mystery than it was later when a scientific consciousness had developed. We do not know precisely what magnetism is, even today; but we do know how to produce it and how to control it, and knowing this, we have developed certain theories as to its nature, or rather, to the mechanism of its production. Magnetism, apparently, is something similar to the displacement current[2] of electricity in an insulator—a certain kind of a strain in space, a modification, perhaps, of the geometry of space in the neighborhood of moving electrons.

## HISTORY OF MAGNETISM

Man's first ideas about magnetism were vague and fanciful. From very earliest times, a certain mineral had been known which possessed the remarkable property of attracting iron; it was a natural magnet and was called lodestone. In time, various theories or rather, legends arose to account for its strange attractive properties. Today lodestone is known to be a magnetic oxide of iron but in those early days nothing was known about it, other than that it had properties which no other substance had. Legend attributed the discovery of lodestone to a Cretan shepherd who was so strongly attracted to the earth by his iron tacked sandals that he dug to ascertain the cause. Imagination was stimulated by the mysterious attractive powers of the magnet and many fables sprang up around it. In one of the voyages of Sindbad the Sailor, a mountain is described which was so strongly magnetic that it drew all the nails out of the ship at a great distance, so that all perished except, of course, Sindbad. This story has its origin in ancient legend. The imagination of these early observers, indeed, was developed to a greater degree than was their capacity for accurate observation and reason.

Among the Greeks, Thales of Miletus[3], who first noticed that the rubbing of amber caused it to attract bits of paper, is credited with a knowledge of the attractive power of the lodestone. This attraction he attributed to a soul in the substance.

Knowledge of the compass dates back to classical antiquity and vague reference to its north (or south) pointing properties are found in widely scattered literature. The ancient Chinese are usually credited with having had first knowledge of it but specific evidence seems to be lacking. The first definite reference to polarity is found in a dictionary of A.D. 121 where it is stated that the south pointing property may be imparted to iron by blows, or by means of the lodestone.

It is to a man named Peter Peregrinus, however, that the earliest systematic study of magnets is due. This pioneer among research workers sets forth his discoveries in magnetism in a letter to a soldier friend in the year 1269, and this letter is the first treatise on the subject. Peregrinus recognized clearly the importance of experimental research, and his appreciation of method is seen in his fashioning a lodestone in the form of a globe and drawing lines upon it indicating the direction in which the magnetic needle tended to set itself. From the similarity of these to meridians, he was led to the invention, by analogy, of the term magnetic "poles." He distinguished between the north and the south poles by placing the stone in a wooden skiff, which was floated in water, and noting which end pointed to the north.

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[1]This, obviously, is a crude way of expressing it. Electricity, as a matter of fact, is not stored in the condenser—what is stored is energy, the potential energy due to the separation of positive and negative electric charges. The transformation of this potential electric energy into kinetic electric energy gives rise to the magnetic field.

[2]Electricity—What It Is and How It Acts. Vol. I, page 102.

[3]Ibid. Chapter I.

While Peregrinus' magnetic investigations were remarkable, it was not until some 300 yr. later that any real scientific advance was made in the knowledge of magnetism. In 1600, William Gilbert published his book "On the magnet, magnetic bodies also, and on the great magnet, the earth." Gilbert clearly discriminated between magnetic and electric actions, discovered that a piece of iron was not attracted if red hot, but that it regained its normal properties on cooling and found that iron could be magnetized by hammering when held to point north and south. His most important discovery, of course, was the fact that the earth itself is a magnet which explained the then known facts about terrestrial magnetism. This conception of the earth as a magnet at once swept away all mystery as to why the compass points north and south and provided a perfectly logical explanation in its stead.

The discovery of the law of force between magnetic poles is usually credited to John Michell. In a treatise on Artificial Magnets, he sets forth the principles of magnetic theory; that each magnetic pole attracts or repels exactly equally at equal distances in every direction and, that "the attraction and repulsion of magnets decreases as the squares of the distances from the respective poles increases." This important deduction is the one on which the mathematical theory of magnetism is based. Michell was the first inventor of the torsion balance which he utilized in his experiments on magnetic forces. It was not until 1785 when C. A. Coulomb carried out his classical investigations, that the inverse square law of force between magnet poles was established experimentally with satisfactory precision. The mathematical theory of magnetism was developed before a satisfactory explanation of magnetism was available.

The next important step was the discovery of the relation between magnetism and electricity. In 1819 Hans Christian Oersted found that a magnetic needle placed parallel to a current carrying conductor tended to set itself at right angles to the current. This discovery was followed rapidly by other investigations and in 1820 André Marie Ampère showed experimentally the mutual action of current-bearing circuits.[4] In the same year Arago succeeded in magnetizing a piece of iron by an electric current, and shortly afterwards the whole subject of the mutual action of currents and magnets was dealt with comprehensively by Ampère in one of the most celebrated memoirs in the history of physics.

No investigation or discovery in the field of magnetism equaled in importance nor led to such far reaching consequences, however, as the one made in 1831 by Michael Faraday; that is, the discovery of the law of electromagnetic induction upon which all our modern electrical machinery is based. And nobody was more fit or better equipped to discover this law for in no more than ten full days of research, between August and November, this master of method and observation unravelled all the essential features of electromagnetic induction. Faraday's views were given mathematical expression by his great follower, James Clerk Maxwell in his classical Electromagnetic Theory of Light.

So much for the early history of magnetism. Our object here is to present as briefly and as clearly as possible the modern conceptions and theories of magnetism and to show how the electron is involved in these theories, for, as will be shown, the electron is not only the basis of all electrical phenomena but serves also to account for magnetism. This naturally is to be expected for if the electron is the universal entity we have assumed it to be it must account for magnetic phenomena as well as electrical phenomena.

[4]Ibid. Chapter XII.

### Fundamental Principles of Magnetic Action

In previous chapters we have seen how a stream of electrons creates a magnetic field; all that remains now, is to determine whether the electron is responsible, also for permanent magnetism. Before discussing these theories, however, it will be of interest to describe briefly some of the more fundamental magnetic phenomena.

Magnets more or less permanent in nature may be produced in a variety of ways. At first, the only method available was by stroking a piece of iron or steel with lodestone. Aragos' discovery that magnets could be produced by means of an electric current led to the method of magnetizing iron that is now usually adopted, that is, by placing the piece of iron to be magnetized within a coil or solenoid carrying a current. While the current is flowing, the iron becomes strongly magnetized; when the current ceases, the magnetization decreases but a certain amount is retained in the iron. If, instead of iron, suitable steels are used, a much greater degree of magnetization will be retained and thus "permanent" magnets are made. Magnetism can be produced also by hammering as will be described.

Suppose a simple straight bar of steel is magnetized by any of the foregoing methods. If this magnet is dipped into a mass of fine iron filings, the filings will cling to all parts of the magnet but most of them will concentrate around the ends of the bar. These regions are called the "poles" of the magnet and a line joining the poles is called the "magnetic axis." If such a bar is suspended horizontally by a fine silk thread so that it is free to move in any direction, it will come to rest with the magnetic axis in a north and south direction, that is, the magnetic axis will be parallel to the earth's magnetic meridian. The pole which points towards the north is usually called the north seeking or simply the north pole and the opposite one, the south pole.

If two such magnets are suspended horizontally, it can easily be shown that unlike poles attract each other, while like poles repell. The force which is thus exerted between two poles, as has been stated, varies inversely as the square of the distance between them, and as the product of their strengths. This law may be expressed in the form of an equation:

$$F = \frac{m\ m'}{d^2}$$

where F is the force in dynes, m and m′ the strength of the respective poles and d the distance between the poles measured in centimeters. This equation, it will be obvious, is similar to that expressing the force between two electric charges.[5]

The preceding equation provides a convenient way of denoting the strength of a magnetic pole; that is, it defines the unit of magnetic strength, the "unit pole." A unit magnetic pole is such that, when placed (in

[5]Coulomb's law. See Chapter VI.

air) at a distance of 1 cm. from a precisely similar pole, it is repelled with a force of one dyne.[6]

The region around a magnet in which these magnetic effects occur is known as the field of the magnet or simply, the magnetic field. If a compass needle is placed close to a magnet, it will aline itself in a definite direction, due to the magnetic force acting on it. The direction thus indicated by the needle is the direction of the

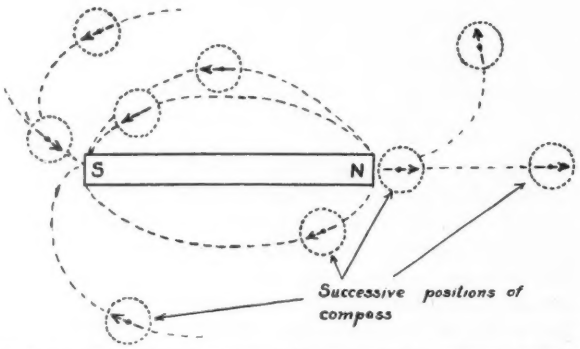


FIG. 2. DIAGRAM, SHOWING HOW THE MAGNETIC FIELD OF A MAGNET MAY BE MAPPED OUT BY NOTING THE POSITION OF A COMPASS NEEDLE AT VARIOUS POINTS

magnetic field (of the magnet) at that point. Ordinarily, that is in the absence of a magnet, the direction taken by a compass needle, is the direction of the magnetic field of the earth, but when placed near a magnet, the effect of the earth's field becomes negligible. If a compass needle is moved around a magnet and its direction, at various points plotted on paper, the resultant diagram will be one of the magnetic field of the magnet. (See Fig. 2.)

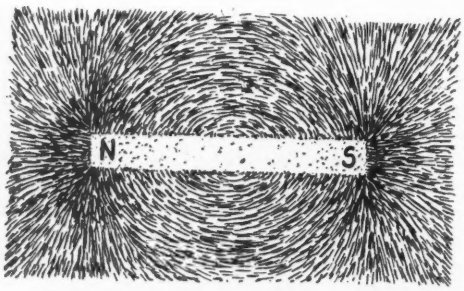


FIG. 3. MAGNETIC FIELD AROUND A SIMPLE BAR MAGNET. THIS DIAGRAM IS PRODUCED BY SIFTING IRON FILINGS ON A SHEET OF PAPER OR CARDBOARD UNDERNEATH WHICH THE MAGNET IS PLACED

A simpler and more effective way of determining the shape of such a magnetic field is by the use of iron filings. If iron filings are sifted from a small sieve on a sheet of pasteboard or paper under which a magnet is placed, the filings will arrange themselves in the direction of the lines of magnetic force emanating from the magnet. The filings thus produce an accurate representation of the field of force. These lines of force, of course, are only imaginary lines along which the attractive or repulsive force of a magnet acts—actually they have no existence, for if they did it would imply a non-uniform field. It is convenient, however, to assume that they exist as it enables us better to understand the action of magnets.

These lines of force are assumed to leave or "flow" from the north pole of every magnet, to curve around in the outer medium and to enter the south pole, each line completing an unbroken, continuous path or circuit through the magnet itself. These lines are always complete, that is, a magnetic field cannot exist with only one pole. If a magnet is broken in half or into a number of small pieces, the lines of force will extend from section to section through the intervening medium. When a magnet is broken in this manner, each part or section automatically, so to speak, forms its own north and south poles, opposite poles being adjacent as shown in Fig. 4. No matter into how many pieces a magnet is thus broken, each piece will have its own poles. In the case of the iron filing experiment described above to show the shape of the field, each tiny filing virtually becomes a magnet, the north pole of each connecting with the south pole of the one next in line with it.

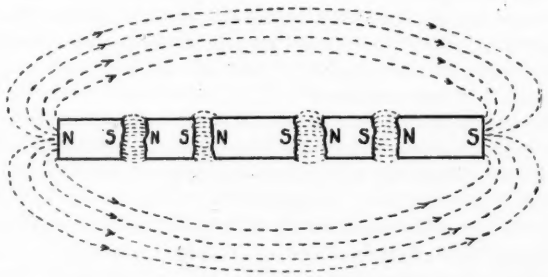


FIG. 4. MAGNETIC CIRCUIT THROUGH A BAR MAGNET WHICH HAS BEEN BROKEN INTO A NUMBER OF PIECES
Note, that the adjacent ends of the pieces have poles of opposite polarity. The lines of force across the air gaps thus formed act like rubber bands tending to pull the pieces together.

Each line of force can be thought of as resembling an invisible stretched rubber band and there is a rubber band tension along every line trying to shorten it. The lines in fact are very similar to the conception of electric lines of force between opposite electric charges. Each line also exerts a sideways push in all directions tending to crowd adjacent lines away from it.

A magnetic circuit, therefore, is the path followed by magnetic lines of force of a magnet. Although lines of force are often spoken of as "flowing" from the poles it must be understood that there is no actual flow of something in a magnetic circuit as there is in an electric circuit. The field is really nothing more than a state or condition of strain in space.

While lines of magnetic force can exist in almost any material as well as in a vacuum, certain "magnetic" materials such as iron and steel "conduct" them with much more ease and readiness than other materials. Such "magnetic" materials seem to offer little opposition to the lines of force. Because of this fact, if a piece of iron or steel is placed in a magnetic field, say in air, nearly all of the field will be concentrated in the iron. This is shown in Fig. 5. Here at A is shown a bar magnet and its field in air. It is quite symmetrical. At B is shown the same magnet but with a soft iron bar placed near it at an angle. Now, the field, it will be noted, is unsymmetrical, nearly all of the lines of force passing through the iron bar.

[6]For the definition of the dyne, Chapter XVIII, page 181. Electricity—What It Is and How It Acts.

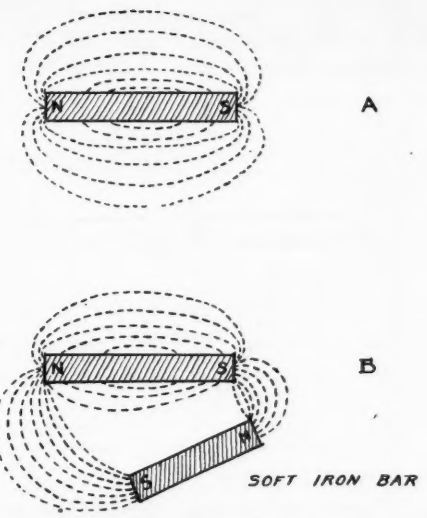


FIG. 5. DIAGRAM SHOWING THE PRINCIPLE OF MAGNETIC INDUCTION

At A is shown a simple bar magnet and its field. At B is shown the same magnet but with a bar of soft iron placed close to it. The iron bar, thus, becomes a magnet by induction.

This diagram also illustrates another principle of magnetic action, i.e., that of magnetic induction. Magnetism can be imparted by a magnet to a magnetic substance without the two being in actual contact. In Fig. 5B, while the bar is in the position shown, it is magnetized through the influence or induction of the bar magnet near it. This, of course, is really what happens when a magnet is made by placing a bar of iron or steel within a solenoid carrying an electric current. We know that a magnetic field is produced by the solenoid and by placing the iron in this field it becomes magnetized by induction.

When a magnet is produced in this manner, by induction, the two poles of the magnet and the bar to be magnetized nearest together will be unlike, as shown in Fig. 5.

It was stated in a previous paragraph that magnets could be produced by hammering. This is merely an application of magnetization by induction in which the magnetic field of the earth itself is employed. If an annealed iron bar such as shown in Fig. 6 is tested, it will show no magnetism if supported horizontally in an east and west position. If, however, this bar is held in the direction of the earth's magnetic meridian (indicated by a dip needle) and the bar struck a sharp blow with a hammer, it will be found upon testing with a compass needle that it has become magnetized. Its north end will be found to be north seeking and its south end south seeking. If the bar is then turned end for end, and again struck with the hammer, its polarity will be found to be reversed. These effects are due to the inductive action of the earth's magnetic field.

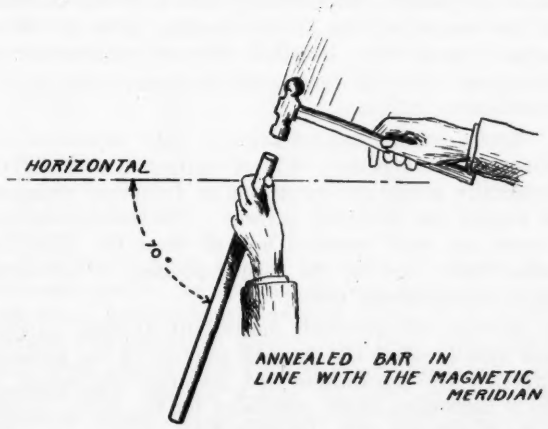


FIG. 6. MAGNETIZING AN IRON ROD BY THE EARTH'S MAGNETIC FIELD

If the rod is held parallel to the earth's magnetic meridian and struck a sharp blow with a hammer, it will become magnetized by the earth's magnetic field.

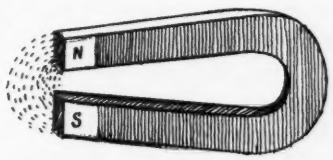


FIG. 7. BY DRAWING THE POLES OF A BAR MAGNET AS CLOSE TOGETHER AS POSSIBLE A HORSESHOE MAGNETIC IS FORMED

The ability of a material to conduct magnetic lines of force or magnetic flux, is called its permanence. Thus iron and steel have a much greater permanence than air or wood. The measure of this property of a substance is called its permeability.

When the bar of iron is introduced in the magnetic field of the bar magnet shown in Fig. 5B, the number of lines of force in the region now occupied by the iron bar is increased enormously over that which existed in the air previously, because of the greater permanence of iron over air.

It is because of the great permanence or permeability of iron that it is used universally for the magnetic circuits of electrical machinery. In the making of permanent magnets also, because of the greater permeability of iron over air, the two poles (north and south) of a magnet are placed very close together by bending the bar into the shape of a V or horseshoe, hence the term horseshoe magnet. In this way, the path of the magnetic circuit through the air is shortened to a minimum and the field strength increased.

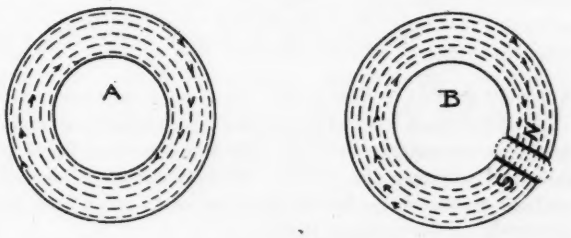


FIG. 8. RING MAGNETIC CIRCUITS

A. A closed ring having no external field. Such a magnet has no poles. B. A ring magnet with an air gap.

When the poles of a magnet are brought together so as to eliminate the "air gap" entirely, a so-called ring magnet is produced. A ring magnet has no poles and no appreciable external magnetic field, although the ring itself may be very strongly magnetized. The instant, however, a piece is cut out of the ring, two powerful

poles will be produced and we have the elementary form of the magnetic circuit so widely used in motors and generators. The closed ring magnetic circuit is used in transformers and in certain electrical instruments.

It was shown in a previous paragraph that when a bar of iron is magnetized by induction or when a magnet is cut into a number of smaller magnets, the adjacent poles produced will be of opposite polarity. Lines of force stretching across the air gaps so produced have a rubber band tendency to shorten themselves; therefore, the effect is to draw the respective poles together. This explains why unlike poles attract each other.

If, however, two like poles are placed adjacent to each other as shown in Fig. 9B the lines of force no longer pass from one magnet to another, but the lines from each north pole will seek the south pole of the same magnet. Thus, the condition shown in the figure is obtained. It will be evident that in the space between the two magnets, the lines of force tend to crowd each other apart and as a consequence the magnets will repel each other.

A permanent magnet as a rule can have only two poles, but an electromagnet can be made to have any number of poles in the same bar of iron. This condition can be brought about by reversing the direction of winding along the bar. The poles so produced are called the consequent poles, and, of course, being of like polarity they tend to repel each other.

These are the simple facts regarding magnetic phenomena. In a subsequent article, we will discuss various kinds of magnetism or rather the different behavior of different materials in a magnetic field.

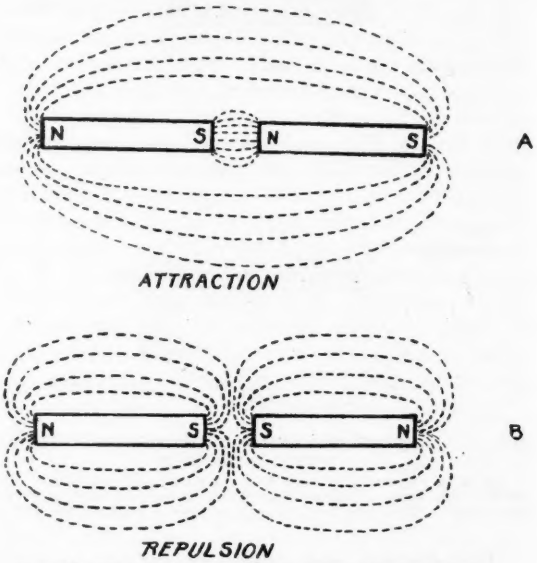


FIG. 9. DIAGRAM SHOWING ATTRACTION AND REPULSION

At A the two bar magnets are arranged with opposite poles adjacent. The lines of force from one pole face enter that of the adjacent pole face. Since the lines tend to shorten, an attractive force is produced. B. When the magnets are arranged with like poles adjacent, the lines of force leaving one pole face no longer seek the adjacent pole face but pass to the other end of the same magnet. A crowding action takes place between the magnets which tends to push them apart.

# Selecting Motors for Industrial Service

SPEED AND TORQUE CONDITIONS OF THE DRIVEN MACHINE, COST OF POWER, SIZE OF FEEDERS AND NECESSITY FOR POWER FACTOR CORRECTION DICTATE MOTOR SELECTION

WHAT FACTORS must the power engineer consider when selecting motors for driving industrial and process machines? Must the machine and drive be designed to meet the specific characteristics of certain motors or may they be designed so as to meet best the demands of the process itself?

Fortunately the motor and motor control equipment has reached such a high state of development that the drive; direct, belt, chain, gear, clutch or lineshaft, may be selected to best meet the needs of the driven machine with assurance that motors are available with characteristics to meet the conditions imposed.

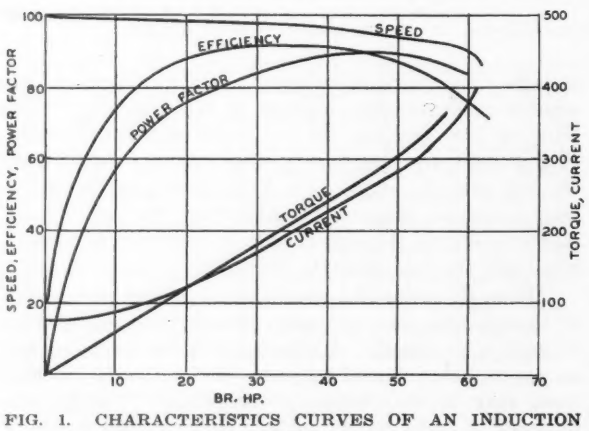


FIG. 1. CHARACTERISTICS CURVES OF AN INDUCTION MOTOR

Purely local or economic conditions, however, may enter the problem and influence not only the selection of the motor but the driven machine as well. To a certain extent the available current, alternating or direct, and with the former the frequency, will have a considerable influence.

Again, special motors are not only expensive but often require expensive control equipment and not infrequently motor generator sets or frequency changers to supply the required current. Alternating current motors are more common and of these the induction motor takes care of the larger portion of industrial motor requirements today.

As such, the induction motor with quantity production usually offers the cheapest solution of the problem, although the advantages and growing application of the synchronous motor, especially for the slower speeds, make it a factor to be considered.

The squirrel cage induction motor is a constant, or nearly constant, speed machine while the slipring or wound rotor induction motor can be operated at variable

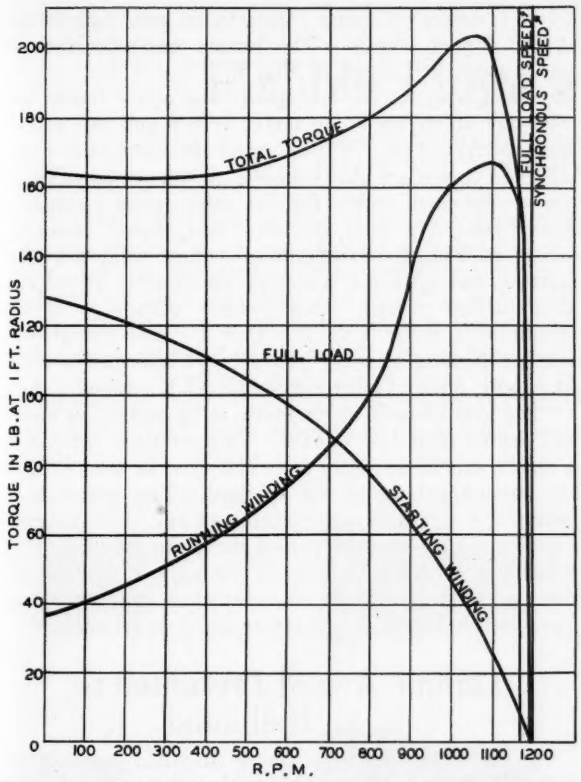


FIG. 2. TORQUE CHARACTERISTICS OF A SPECIAL INDUCTION MOTOR WITH TWO WINDINGS ON THE ROTOR

speeds down to a practical limit of about 50 per cent. Induction motors with primary windings capable of various pole grouping are also available. These are known as multispeed motors and can be operated at any one of several different speeds, although because of the expense, more than two speeds are not common. Synchronous motors, of course, operate at constant speed. Because these three types of motors pull the bulk of the industrial load, the present discussion will be limited to them.

### Speed Depends on Frequency

Squirrel cage and synchronous motor speeds depend upon the number of poles and the frequency of the available power, the following tabulation giving the speed combinations with different power supplies.

| Speed | 25 cycle | 50 cycle | 60 cycle | 125 cycle |
|---|---|---|---|---|
| 2 pole | 1500 | 3000 | 3600 | 7500 |
| 4 pole | 750 | 1500 | 1800 | .... |
| 6 pole | 500 | 1000 | 1200 | .... |
| 8 pole | 250 | 750 | 900 | .... |
| 10 pole | ... | 600 | 720 | .... |
| 12 pole | ... | 500 | 600 | .... |
| 14 pole | ... | 429 | 515 | .... |
| 16 pole | ... | 375 | 450 | .... |
| 18 pole | ... | 333 | 400 | .... |
| 20 pole | ... | 300 | 360 | .... |

The speeds given in the table are, of course, synchronous speeds. In the induction motor there is, except at no load, a certain amount of slip so that they actually run somewhat slower than these speeds indicate. Full load speed is marked on the name plate, for instance—the common 4-pole, 60-cycle, squirrel cage induction motor being marked full load speed 1750 r.p.m. or 1740 r.p.m. depending upon the characteristics of that particular design. Two-pole, 125-cycle, frequency motors are used largely for direct connection to woodworking machines where high rotative speeds are desired.

Because of the cheapness, simplicity and ease of control of the constant speed motor, it is often used when the driven machine itself might perhaps be served somewhat more satisfactorily by some other type. Again, the speed demand may be for 1450 r.p.m. but a 1750-r.p.m. motor with a belt, gear or chain[1] drive will not only prove to be the best solution but offer advantages of motor location and position which direct drive would not give. Many process and industrial machines require variable speed and here again the constant speed motor can be satisfactorily applied by utilizing one of several types of mechanical variable speed changers.[2]

With all these devices, what features of the motor must be considered? Primarily the motor must be of such a size and design that it will start the load, accelerate it and carry it for the required period of time without overheating. Because of this the starting and running torque must be investigated. For instance, centrifugal pumps have a low starting torque, while a machine with heavy moving parts, such as a paper machine, has a high starting torque.

Second, the slip or speed regulation of the motor must be given due consideration. Some machines require constant speed over the entire range of load, while with others a slight variation is permissible. Synchronous motors operate at constant speed, squirrel cage induction motors at almost constant speed, while the slipring induction motor with a given resistance in the secondary circuit will show a considerable decrease in speed as the load increases.

### Full Voltage Starting Advantageous

So much for the requirements of the load or driven machine. In addition to this, the power requirements of the plant must be considered. The starting current is important, both to prevent overload of switches, circuit breakers and feeders, and to prevent disturbances to other equipment, particularly generating

[1]See Machine Drive, page 293, Mar. 1, 1930, and Speed Reducers and Variators in Power Plants, page 1083, Oct. 15, 1928.

[2]See Variable Speed Drives Aid Economy, page 455, Apr. 15, 1930.

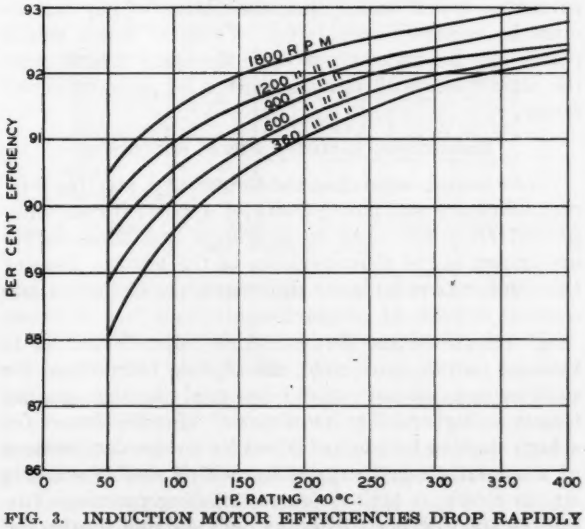


FIG. 3. INDUCTION MOTOR EFFICIENCIES DROP RAPIDLY AS THE SIZE AND SPEED DECREASE

equipment and lights. One of the disadvantages of the squirrel cage induction motor is its high starting current. In motors of above 7½ or 10 hp. it is usually necessary to reduce the voltage applied across the motor terminals at starting by means of a resistance or compensator.

The exact size of ordinary motor which can be started with full voltage depends upon the size of the individual system on which it is operated. Starting large motors of this kind is usually prohibited when current is purchased; however, the advantages of full voltage starting, requiring only a line switch, were so great that a special full voltage starting type of squirrel cage induction motor has been developed.

Economy is also important especially with large motors. For this reason, efficiency and power factor cannot be neglected. Efficiency shows up directly in the power bill whether electric power be made or purchased while power factor may be of major or minor importance. If power is purchased and the power contract contains a penalty for low and premium for high power factor, this item must receive more attention than if power is generated with sufficient capacity and the power factor of the plant as a whole is fairly high. If, however, generating capacity is limited and feeder currents are well loaded, the power factor of new motors must be carefully considered. Twice as much actual power can be transmitted over the same circuit with the same losses with unity as with a 50 per cent power factor.

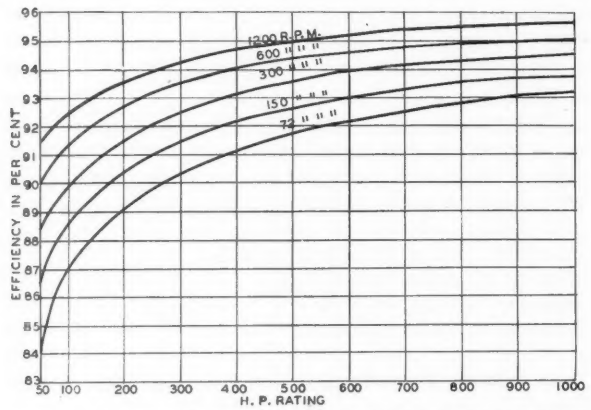


FIG. 4. SYNCHRONOUS MOTORS HAVE A RELATIVELY HIGH EFFICIENCY AT LOW SPEEDS

### Synchronous Motor Field Widening

Information regarding the torque, slip, starting current, efficiency and power factor of a motor is commonly plotted from test data as in Fig. 1 and these curves are known as the characteristics of the motor. Data of this kind are available for different types of motors and serve as a basis of comparison.

If a high torque, that is a high ratio of starting to running torque, is required, the slipring rather than the squirrel cage motor should be used as the starting torque is higher. The requirement of some drives for a high starting torque motor has led to the development of a special squirrel cage motor with a double winding on the rotor. A high resistance winding functions during the starting period to give high starting torque and a low resistance winding functions to give high torque at the higher speeds. The torque characteristics of such a motor are shown in Fig. 2.

When designed for low speeds, the power factor and efficiency of an induction motor is low and the cost is comparatively high. Variations of efficiency with motor sizes and speeds are shown in Fig. 3. On the other hand, the synchronous motor for the same speed conditions has a relatively high efficiency and power factor as shown by Fig. 4. Synchronous motors today are self-starting and synchronizing and are equally as reliable as induction motors. One distinct advantage of the synchronous motor is the fact that it can be operated at leading, lagging or unity power factor and can be made to supply power factor correction at a minimum cost.

The synchronous motor starts as an induction motor and cannot start heavy loads. To meet these conditions a clutch can be added or a special type of motor called the super-synchronous can be used. This motor is in reality a clutch and motor combined and is so designed that during the starting period the stator frame rotates. After synchronizing, a brake is gradually tightened and the stator slowed up, the rotor starting and picking up the load gradually as the stator speed is reduced.

## Lamme Award Presented to R. E. Hellmund

Rudolph E. Hellmund, chief electrical engineer for the Westinghouse Electric and Manufacturing Co., received the distinguished honor of the B. G. Lamme Award for 1929 as the American Institute of Electrical Engineers convened at Toronto.

The medal, regarded as one of the outstanding tributes paid in electrical engineering and ranking with the Edison Award in prizes under custody of the A. I. E. E., is in gold and also carries a bronze replica. Mr. Hellmund is the second to receive the honor since its founding by the late B. G. Lamme, the eminent electrical engineer.

It is significant that the recipient of the Lamme Award should have worked with the donor in previous years. Mr. Hellmund has distinguished himself as a designer of induction motors. Before becoming chief electrical engineer for Westinghouse, he was chief designer for Western Electric and affiliated with William Stanley, developer of alternating current and alternating current transformers.

Mr. Hellmund is a German by birth and education. Before coming to America, he graduated from the Charlottenberg University. Among his important interests are foreign technical connections in the electrical industry.

In addressing the Institute following the presentation of the Lamme Medal, Mr. Hellmund urged that engineering students should in general enter industries after receiving bachelors' degrees and continue their studies for higher degrees in connection with practical work.

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Permanent hardness of water is caused by soluble salts which are not precipitated by boiling. They consist of sulphates and constitute the real problem of feedwater treatment. Temporary hardness is caused by carbonates which begin to precipitate at 212 deg. F.

# Fusible Plugs as Safety Devices

CHARACTERISTICS OF FUSIBLE PLUGS IN SERVICE, THEIR DESIGN AND INSTALLATION. BY C. C. CUSTER

AS FIRST invented, it seems that the fusible plug was used in the crown sheet of a firebox type of boiler and was supposed to blow whenever the water level receded below the plug. The metal for use in the core is tin, which was selected because it melts in its pure state at or about 442 to 450 F. In a fire-box type of boiler with the plug installed directly over the fire in the crown sheet, when the plug blows it gives the alarm to the fireman and also is effective in discharging steam directly into the burning fuel, thus quenching the fire.

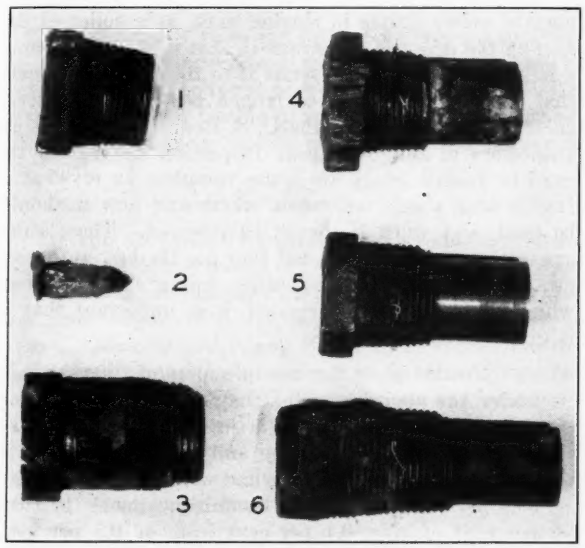



FIG. 1. SAMPLES OF FUSIBLE PLUGS WHICH HAD SEEN SERVICE AND WERE COLLECTED BY THE AUTHOR

The locomotive firebox boiler, however, is much less used than formerly and in most other types of boilers the fusible plug can be depended upon only to make enough noise in blowing to alarm the fireman and effectively to lower the pressure, as when forced draft is used, or oil or gas burned, with the plugs located as they are in many types of boilers they cannot be effective in putting out the fire. Nor can the fusible plug be depended upon in all cases entirely to save the boiler from damage in cases of low water. At its best, it is not 100 per cent perfect as a safety device. It may be of wrong design, be improperly placed, be improperly maintained, deteriorate in use, any of which conditions may cause it to blow too soon, too late, or not at all.

## APPLICATION OF FUSIBLE PLUGS TO VARIOUS TYPES OF BOILERS

Some boilers are of such design that they cannot easily be protected by fusible plugs and in some other types the fusible plug is of doubtful value. Also in boilers to be operated with steam pressures in excess of 225 lb. pressure, the common tin lined plug cannot be recommended as the temperature of the steam is working up too close to the melting point of tin, so that the plug is liable to blow even with the water level well above the allowable minimum.

Fusible plugs have attained the greatest popularity in marine service especially in connection with the Scotch marine type of boiler. Here the fusible plug is screwed into the top of the combustion chamber which is a heavily stayed heating surface that is first to become dry. The plug generally blows before the sheet is distorted or injured.

The same cannot generally be said of the ordinary return tubular boiler where the water generally recedes below the second row of tubes from the top before the plug gets hot enough to blow and the consequence is

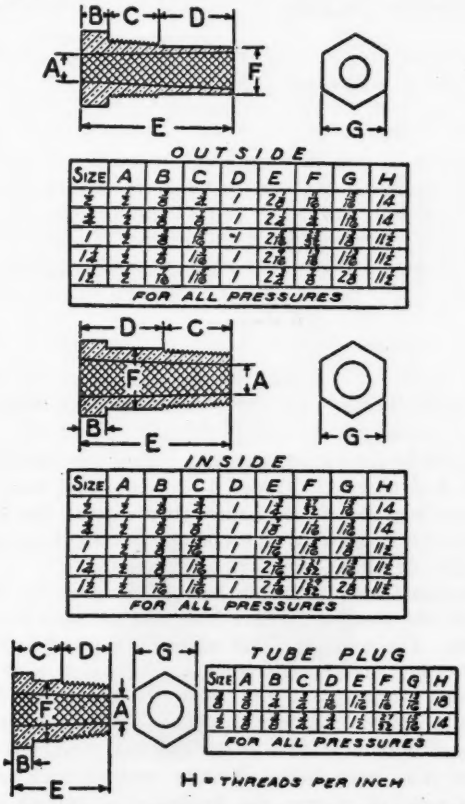



FIG. 2. FORMS OF FUSIBLE PLUGS WHICH CONFORM TO THE A.S.M.E. CODE

that there will be some tubes loosened in the rear head and will need expanding.

Scotch marine boilers used on war vessels are generally equipped with fusible plugs but on other types of boilers, especially the water-tube type the fusible plug is not much favored, for if, in the presence of an enemy, a quick get-away is desirable, the blowing of a fusible plug might be a disastrous thing to happen.

In some types of boilers, the fusible plug is of doubtful value. For instance, recently I saw a firebox boiler

(down draft type with water grates) which was fired up with only a little water in it. The water grates and first pass row of flues were all damaged beyond repair before the fusible plug functioned. This was a case of slow fire and as the fusible plug was above the second flame pass, the flames were considerably cooled before reaching it and the damage was done before the plug got hot enough to blow.

Another case somewhat similar was a welded type heating boiler. In this boiler, the water got down below the water glass and about six rows of flues were uncovered, in the presence of a brisk oil fuel fire. The fusible plug did not blow, nor could any particular damage to

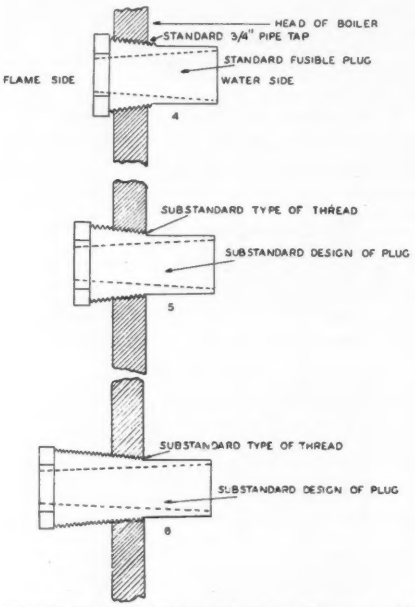



FIG. 3. SECTIONS THROUGH PLUGS NOS. 4, 5, AND 6 OF FIG. 1

the boiler be detected afterwards. This was because the flames had traveled through two passes and their temperature was so reduced before they reached the fusible plug that they were not hot enough to melt the plug nor to do the dry tubes any serious damage.

Another type of boiler hard to protect by fusible plug is the vertical tubular boiler often used on steam shovels. The code says that with this type of boiler the fusible plug shall be placed in a tube which is of extra thickness of walls so that the plug will have a full thread where it screws in. As this tube is of smaller internal diameter it is impossible to get the flue cleaner through it, and it is often found entirely stopped with soot, in which case, of course, the fusible plug cannot be expected to function in case of low water, as no flame will be going through this flue.

Other common causes for fusible plugs failing to perform are: (a) When the bricklayer places the baffle plate too low on the rear end of a horizontal return tubular boiler so that the head of the fusible plug is covered up by the brick work and does not stand out in the flame pass. Another case is where the fusible plug is placed in the crown sheet of a down draft type of firebox boiler or in various locations in different types of boilers where there is a dead air space, that is a space not directly in the path of the flames.

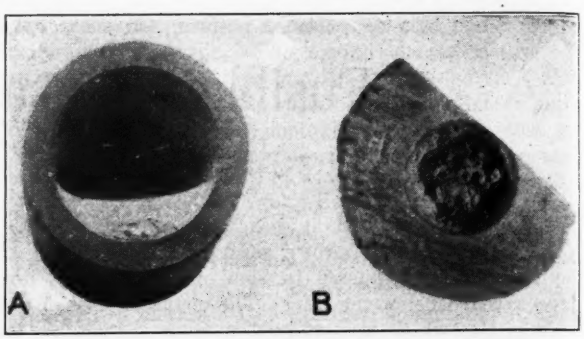
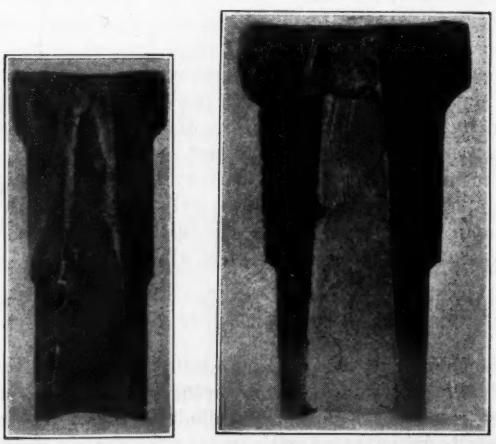



FIG. 4. A. APPEARANCE OF WATER END FILLING MELTED DURING TEST BUT "INFUSIBLE CRUST" IN FIRE END PREVENTED BLOWING; B. APPEARANCE OF FIRE END SHOWING "INFUSIBLE CRUST" WHICH HAD REPLACED FILLING DURING SERVICE

The fusible plug is considered as an extremely important safety device in marine work, as a boiler explosion on the ocean is disastrous in that it generally blows a hole in the ship which sends it to the bottom so quick that there is no chance to launch boats. The general rules and regulations of the U. S. Board of Supervising Inspectors of the Steamboat Inspection Service in regard to fusible plugs are quite complete as to what a fusible plug should be, when, where and how it should be used, and when it should be renewed. These rules are too long to quote here but they are the best authority on the subject. The following paragraph, however, which has recently been revised, is so important that it is given verbatim:

> "Fusible plugs for use in boilers of steam vessels under the jurisdiction of the Steamboat Inspection Service shall be made of a bronze casing with the bore tapering continuously and evenly from end to end, and filled from end to end with tin not less than 99.3 per cent pure and to contain not more than 0.1 per cent of zinc, 0.1 per cent lead, or 0.5 per cent copper, and in no case shall it contain more than 0.7 per cent total impurities. The small end of the bore may be countersunk not more than ¼ in. in depth and width, but no recess, thread or cavity other than this countersink shall be allowed."



FIGS. 5 AND 6. SECTION SHOWING CRUST IN FIRE END WHICH WOULD PROBABLY HAVE PREVENTED FUNCTIONING

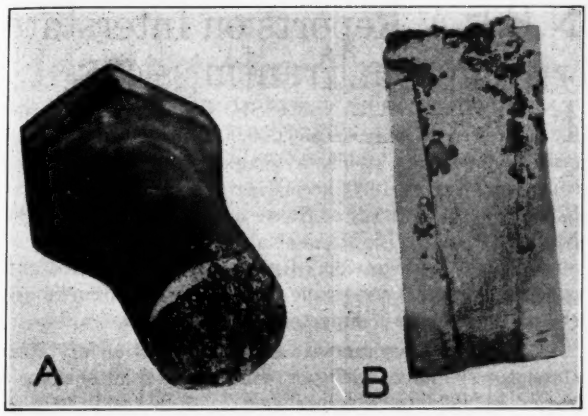



FIG. 7. ARTIFICIAL INFUSIBLE CRUST PRODUCED IN LABORATORY

The manual of rules can be secured free by applying to the nearest supervising inspector's office. Also of value to the reader is the portion of the A.S.M.E. Boiler code dealing with fusible plugs, particularly the proper location of fusible plugs in various types of boilers as outlined.

### Forms of Fusible Plugs

Acceptable forms of fusible plugs as allowed by the A.S.M.E. Code are shown in Fig. 2. All dimensions are given and these dimensions must be adhered to as there are good reasons why the design should be exactly as shown. Also see cuts A and B of Fig. 8, which show the different designs for plugs meant to be screwed into the plate from the inside of boiler and from the outside of the boiler. These two types are not interchangeable. For instance, if we find that the boiler is tapped with a ¾-in. tap from the inside, an inside type plug must be used. Note that, to function properly:

(a) There must be at least an inch length of plug extending into the water on the inside of the boiler and around which the water circulates to keep it cool.
(b) It is desirable that the projection of any plug beyond the boiler shell into the fire chamber should be a minimum.

The reason for this will be understood by the reader by noting the defective plugs shown in Fig. 1 which are photographs of a number of plugs either defective in design or in application. Figure 1, No. 1 is a common type of substandard plug which is substandard because it does not extend one inch into the water. Having no effective cooling surface and coming only flush with the inner side of the sheet, it often limes up then overheats from the outside and blows prematurely.

In this case, the engineer had no other plug handy so he made an emergency repair by driving a spike in the hole; what is left of the spike is shown at 2. A leak showed up in a few days around the spike so he went to a hardware store and bought the plug shown at 3, which is an inside type plug but he screwed it into the shell from the outside. It, of course, went in only flush with the inside of the sheet and having no cooling surface it had already lost most of its tin filling and was getting ready to blow prematurely a couple of days later when the boiler inspector visited the plant and told the engineer he had better change the plug for the right kind immediately.

Note that the taper of the core would be wrong in this case,—the largest diameter being on the outside. In this same picture, No. 4, is a standard plug which the inspector detected had been filled with babbit by the engineer, and was condemned for that reason. The engineer used some old babbit, half dross, out of a ladle. This dross was of course mostly metallic oxides that were so infusible as to be of no use in a fusible plug.

The plug shown as No. 5 in the same picture is a plug that has a long and tapering screw thread which is bound to bottom somewhere if the hole happens not to be tapped out correctly. In nine cases out of ten, however, the hole is tapped out correctly and as a consequence the plug is screwed in only to a depth of three threads, which leaves too much of the head exposed to the flames. The characteristic of a plug in such a position is that it begins to lose some of its tin core just as soon as it is installed and it is a matter of only a few months when over half of the core will sometimes be gone.

Then, again, the tin sometimes merely oxidizes and remains in the fire end of the plug where it refuses to melt at the proper temperature. Just how the plugs No. 4, 5 and 6 screwed into the shell is shown in Fig. 3.

Plug No. 6, shown in Fig. 1 is also of faulty and substandard design in which this same fault is further accentuated, having, as will be noted, almost half its total length sticking out into the flame pass. Part of the core was gone and the part that was left was probably changed to the infusible oxide.

### Laboratory Tests of Used Plugs

It has long been known that fusible plugs would sometimes fail to function but the January, 1930 issue of the Bureau of Standards Journal of Research gives the results of the test in the government laboratory of

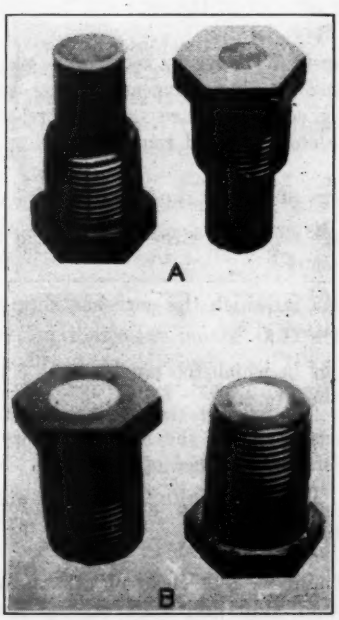



FIG. 8. STANDARD TYPE OF FUSIBLE PLUGS

184 fusible plugs taken at random from those removed by inspectors from steamboats during their yearly inspections, and these tests throw additional light on the subject. These plugs were tested out in special apparatus designed to approximate actual service. The data of these tests are illuminating as to just how fusible plugs deteriorate in service. See Figs. 4, 5 and 6 which are taken from the government report.

As the plug remains longer and longer in service, the fire end of the core begins to take on more and more the appearance of the comparatively infusible tin oxide and the metallic tin retreats toward the water end of the plug. Perhaps the tin core is not well soldered to the containing ferrule as is shown in section, Fig. 5, in which case water will begin to seep through and augment the infusible mass at the fire end with deposits of calcium sulphate, calcium oxide or other salts. Of the 184 plugs tested about 7 per cent of them blew too soon and 10 per cent of them failed to function when heated under steam pressure to the melting point of tin.

It should be understood also that of those that did function the plugs had a considerable difference in their melting point, many of them running up to a temperature 15 to 25 per cent above the melting point of tin before they functioned. The average length of service of these plugs was 10 mo. One plug removed after only two months' service failed to operate. All other plugs that did not function had been in service at least 8 mo. The maximum length of service permitted by the steamboat inspection service is 18 mo.

From this the engineer may draw the following conclusions: First it is best to find out which way the hole in the boiler is tapped—from the inside or the outside, in order to determine whether to order the inside type fusible plug or the outside type.

It is best to specify that the plug be "U. S. Steamboat Standard" in which case it will be manufactured under government specifications and it will come with the maker's name stamped across the metal of the head and the heat number of the core will be stamped on both ends of the core.

It will be best always to keep spare plugs on hand. Whenever fusible plugs that are in use are inspected, the following conditions are sufficient reasons for condemning the old plug and requiring a new one.

(A) Plugs of wrong type or defective design.

(B) Plugs that leak either around the thread or at the core.

(C) Plugs in which the core has slipped or bulged at either end.

(D) Plugs in which too much of the core is missing at the fire end.

(E) Plugs in which the fire end shows the characteristic appearance of tin oxide.

(F) Plugs which have been in use for too long a time.

Plugs should be kept clean of ash and corrosion on flame side and mud and scale on water side. Plugs should be inspected at every boiler cleaning time.

# N.E.L.A. Reports on Interstate Power Transmission

INTERSTATE TRANSMISSION of electric power amounted to only 10,856,000,000 kw-hr. of the total of 91,656,000,000 kw-hr. available for distribution to consumers during 1929, according to a bulletin just published by the Statistical Research Department of the National Electric Light Association. The remainder, or 80,800,000,000 kw-hr., 88.2 per cent were generated and consumed within the same State. These figures are exclusive of energy imported from Canada.

Of this relative increase in the proportion of interstate power, from 10.7 per cent of interstate electric power in 1928 to 11.8 per cent in 1929, about three-fourths is accounted for by two power plants, one of which, the hydroelectric station at Conowingo, Md., operated the entire twelve months during 1929, instead of only eight months during 1928, and the other of which, the new State Line, Ind. steam plant, was put into operation during 1929, with the greater part of this output crossing the boundary into the Chicago area. Much of the remaining relative increase is accounted for by temporary changes from the previous year caused by deficiency in rainfall in several parts of the country and by the abnormal industrial activity which characterized 1929, requiring unusual increases in the output of electric power and the demands made by industrial centers.

The combination of abnormal industrial activity and the curtailed output from many hydro-electric plants due to lack of water supply, resulted in increased demands upon steam-generating power stations. This increased the percentage of interstate power in some areas and decreased it in others.

Except for the above factors, the average for the majority of power transferred across State lines during 1929 showed little appreciable change from the general rate of growth in the use of electric light and power in the United States.

The bulletin points out the fact that it is easily possible to obtain larger apparent proportions of interstate power by counting some of the electricity twice. There are many instances where power traverses several states or else crosses the same boundary line several times in its travel from the power house to the consumer and, if each crossing over each State line were counted, it is estimated that the ratio between the kilowatt-hours of electricity moving across State boundaries and the total volume of electricity might come to perhaps 15 per cent. The report of the Statistical Research Department has, however, been based upon the theory that kilowatt-hours should only be counted once in arriving at national figures, much in the same maner as a consignment of shoes shipped from Massachusetts to Minnesota may cross eleven State lines but actually constitutes only one interstate shipment.

The report includes several statistical tables, giving the imports and exports by individual States and tabulates the operations of 31 large generating plants built in whole or in part to serve power markets from which they were separated by State lines. These 31 plants accounted during 1929 for 63 per cent of all interstate power, or 7½ per cent of all the electricity of the country.

# Heating the Erie Railroad's New York Terminal

OIL-BURNING BOILER PLANT, ISLAND FOUNDATION, OIL STORAGE TANKS, TURBINE-DRIVEN UNIT HEATERS ARE FEATURES. BY H. P. SMITH*

NEW YORK CITY is the daily recipient of the largest quantity of perishable produce of any market, and the Erie Railroad Co. found their New York facilities at Chambers Street inadequate to provide properly for the care and distribution of the large volume of this business which it handles.

To increase these facilities, it was decided completely to reconstruct Pier 21, including its bulkhead and upon completion, these improved properties were to be allocated solely for the receipt and distribution of produce.

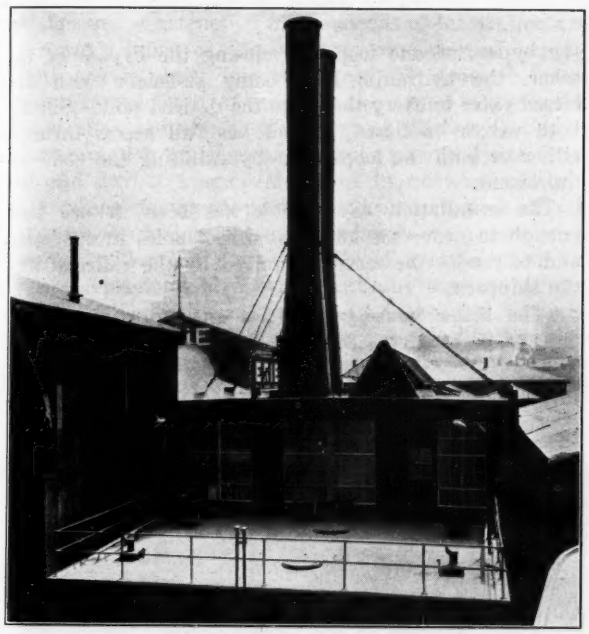


FIG. 1. EXTERIOR OF ERIE TERMINAL BOILER PLANT. OIL STORAGE TANKS IN FOREGROUND

Early in the reconstruction period of 1928, Henry R. Kent & Co. was authorized to design and construct a boiler plant and heating system to provide necessary heat for the New York Terminal, which incorporated the new pier and bulkhead, of approximately 3,700,000 cu. ft., together with the auction rooms, laborers' rest room, offices and lunch rooms located above bulkhead and the ferry house.

Three conditions were to be met in solving the problem. First, the pier, which was 1000 ft. long, was, of course, subjected to extreme exposure. The construction consisted of concrete floor, wood roof with ventilated continuous monitor, corrugated iron siding, and 56 doors for unloading. These doors measured approximately 16 ft. wide by 14 ft. high, and were arranged, in the majority of cases, in groups of three. Maintenance of a temperature at floor level of 40 deg. F. with 0 deg. outside was required on the pier and bulkhead, because certain classes of fruit deteriorate at temperatures below 40 deg., while others of the unripe variety are equally affected when subjected to high temperatures. Open doors during low outside temperatures and concentration of heat were the conditions to be counteracted in the heating problem.

Second, the boiler house should be located as nearly central as possible, yet it must be suitably situated for delivery of fuel and should not occupy revenue-producing space.

Third, selection of proper fuel to meet the conditions was the third of the major problems to be determined.

## TURBINE-DRIVEN UNIT HEATERS

To meet the heating requirements most satisfactorily and economically, a high-pressure system was selected, using turbine-driven unit heaters as the heat distributing medium. These unit heaters, a total of 56 on the pier and bulkhead, operate with an initial steam pressure of 90 lb. delivered to the turbines and exhaust into the unit heater coils.

Due to the necessity of maintaining full headroom on the pier and bulkhead, all piping and equipment was installed above the bottom chord of trusses. This arrangement, coupled with the necessarily long return lines, precluded the advantage of a gravity return, therefore it was necessary to resort to a vacuum system. The long return lines operate advantageously, however, by fulfilling the requirements of a cooling medium to reduce temperatures of returns below the flash point of the 8-in. average vacuum maintained by the vacuum pump in boiler house.

Unit heaters were located equi-distantly on both sides of the pier and bulkhead and were arranged in groups of two, with thermostatic control. Location of the units and thermostatic control resulted in a remarkably uniform temperature throughout, regardless of whether or not the doors were open.

The best site available and the one most advantageously located for the power plant, was between the two ferry slips to the South and paralleling the pier. This location, however, had serious disadvantages, because of the severe shocks experienced upon the docking of boats and the limited area to accommodate the necessary boilers, auxiliary equipment and fuel. To overcome the disadvantage of shock, an island platform, entirely isolated from the surrounding structure, was constructed and on this platform the boiler plant was erected.

## SELECTION OF FUEL

Inasmuch as the Erie Railroad is one of the largest eastern coal-carrying roads, serious consideration was given to the use of coal as fuel. The use of coal obviously necessitates coal handling equipment and storage facilities; there is also the difficult problem of the handling, storage and disposition of ashes. The only alterna-

*Engineer in charge, Henry R. Kent & Co., Engineers and Constructors, Rutherford, N. J.

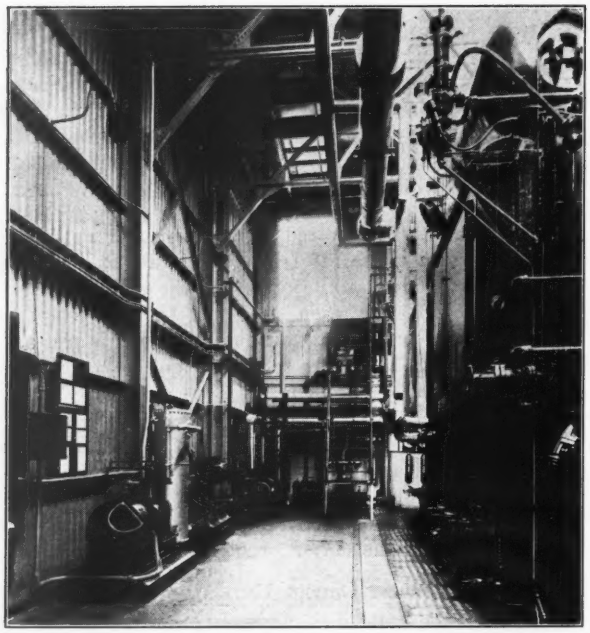


FIG. 2. THREE OIL-FIRED BOILERS WITH ACCESSORIES SUPPLY STEAM AT 90 LB.

tive was recourse to the former expensive procedure of trucking coal to, and ashes from, the plant.

With these objectionable features in mind and after a thorough study of all other phases, no fuel offered a more complete solution to the objections than oil. From the standpoint of economy, it represented an advantage in both lower initial investment and operating costs.

With this decision reached, facilities for oil storage were provided on the same island platform on which the boiler plant was constructed. Two 19,500-gal. oil storage tanks were placed in a concrete enclosure and were arranged with the proper vents and piping facilities for filling by barge delivery.

The Board of Standards and Appeals of the City of New York passes on all oil burning installations in the City of New York and under the regulations governing installations such as the one described, it is specified that "the total storage capacity shall not exceed 50,000 gal., with an individual tank capacity of not exceeding 20,000 gallons." It is also specified that "return lines from burners ..... shall be connected into the supply line near the pump or into the storage tank without shutoff valve in the return line."

Because of these limitations and the advisability of providing for about 40,000 gal. storage, the two tanks mentioned were obviously essential.

### Oil Storage Must Comply with City Regulations

In order to have one tank in service while the other was being cleaned, it was necessary to devise means for delivering the return oil to the tank in service only and still fulfill the condition without valves in the line. To overcome this difficulty, the return from the burners was connected to both tanks, but ahead of each tank a vertical loop was provided, with a valve placed at the bottom of the loop forming a bypass. By this arrangement, the oil may be returned at will to either tank by opening

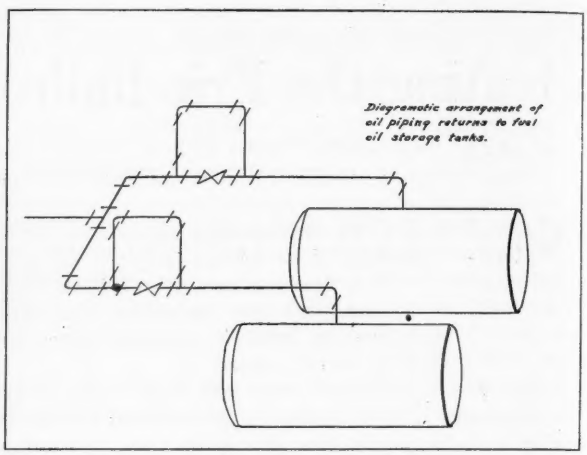



FIG. 3. ARRANGEMENT OF OIL PIPING RETURNS TO STORAGE TANKS PERMITS ONE TANK TO BE IN SERVICE WHILE OTHER IS CLEANED

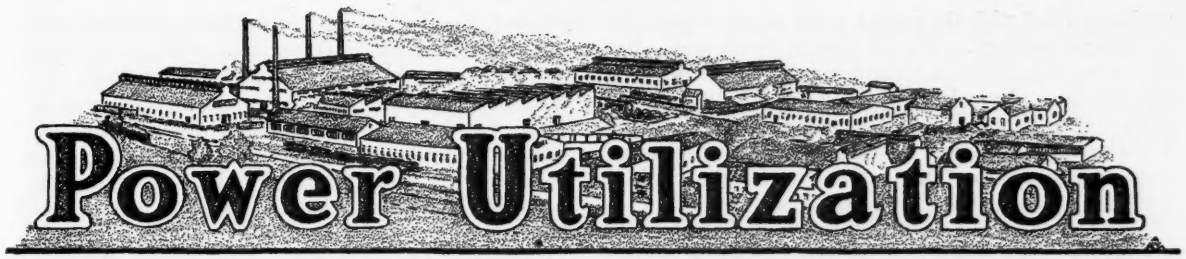
the bypass of one loop and closing the bypass of the other, the hydraulic head being sufficient with one closed valve to carry the oil to the desired tank. Should both valves be closed, the oil has full access through either or both the loops, thereby fulfilling the code requirement.

The installation as a whole has been in use long enough to prove the anticipated economies in operation and to render the service required by the railroad and the shippers.

The boiler house, which has an approximate floor area of 2065 sq. ft., contains the equipment tabulated.

PRINCIPAL EQUIPMENT IN ERIE RAILROAD TERMINAL BOILER PLANT

| | |
|---|---|
| Engineers and constructors (Bldg. const., machy. inst., etc.) | Henry R. Kent & Co. |
| Piling and reenforced concrete to Kent design | Allen N. Spooner & Son, Inc. |
| 3 Boilers, 315 hp. each; cross drum | Combustion Engineering Corp. |
| Oil burning equipment, 3 burners per boiler, 2 oil and air pumps, 1 motor-driven and 1 turbine-driven | Simplex Oil Heating Corp. |
| 2 Boiler feed pumps, reciprocating | Worthington Pump & Machinery Corp. |
| Vacuum pumps | Nash Engineering Co. |
| 1 Air compressor, 5¼ by 5 in., motor driven | Chicago Pneumatic Tool Co. |
| Unit heaters | Buffalo Forge Co. |
| Pipe and bends | Simmons Pipe Bending Works |
| Insulation | H. W. Porter Co. |
| Pressure regulators | Foster Engineering Co. |
| Valves | The Lunkenheimer Co. |
| Vacuum traps and lift fittings | Warren Webster & Co. |
| Temperature regulators | Powers Regulator Co. |
| Steam flow meters | Bailey Meter Co. |
| 1 Surge tank, 2050 gal. | Dover Boiler Works |
| 2 Oil storage tanks | Curtis & Minck |
| 2 Steel stacks | Sotter Bros. |
| Boiler accessories | Reliance water columns with National illuminators; Lunkenheimer blowoff valves; Bayer soot blowers; Ashton pressure gages and safety valves. |




# Labor Reduction in Lubrication

AUTOMATIC SYSTEMS REDUCE COSTS AND PROLONG LIFE OF BEARINGS. BY ALLEN F. BREWER*

LABOR INVOLVED in the usual routine of plant lubrication will be largely dependent upon the design and construction of the means of lubrication and the accessibility of the oil room or source of supply. Both are decidedly important, not only from the viewpoint of reduction of labor in the actual operation of lubrication but also as to the extent that prevention of contamination of lubricants can be assured, both prior to and during usage. Means of lubrication will be a controlling factor in preventing contamination of oils or greases during operation, whereas the manner of storage will affect the possibility of contamination before the products involved are actually put into service.

It has generally been found that labor can be materially reduced by careful study of operating routine and where necessary more or less alteration of the means of lubrication employed on certain types of power plant machinery, with the location of storage as close to the plant as possible.

*Mechanical Engineer, The Texas Co.

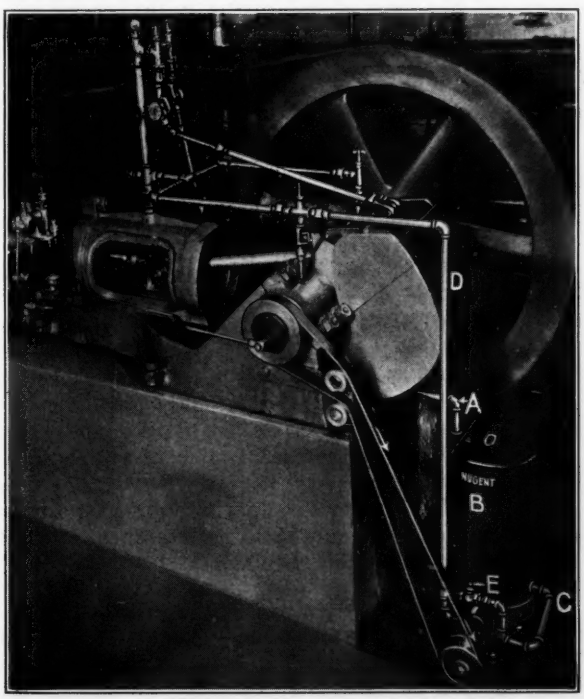



FIG. 1. SIGHT FEED PRESSURE LUBRICATION FOR REFRIGERATION COMPRESSOR

### AUTOMATIC LUBRICATION A FACTOR

In studying means of lubrication and the relationship to labor, it must be remembered that, the more nearly automatic an oiling or greasing system, the less labor will normally be required for the renewal of lubricants and for the maintenance of positive lubrication.

It is interesting to note that automatic lubrication is becoming more and more prevalent for power machinery, being used wherever it is practicable to install the necessary pumps, piping and control.

Where oil cups or compression grease cups are involved, individual attention will be necessary for renewal of lubricants as well as a certain amount of adjustment of the lubricator. This will also hold true for the hydrostatic steam cylinder lubricator. In fact, where individual installations of this latter are involved, it will be necessary for the operator to turn the lubricator on or off each time the engine pump or compressor is started or stopped.

Contrast this with the mechanical force feed lubricator, directly connected to some moving part of the machine. Here all that is necessary is to keep the

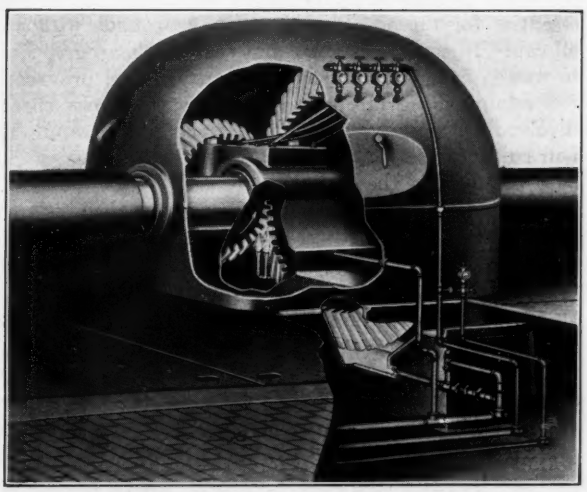


FIG. 2. AUTOMATIC LUBRICATION FOR HOUSED GEARS

lubricator filled with the proper grade of oil to meet the operating conditions. The oil pumps themselves, after once being adjusted to a certain definite flow, will maintain this in a dependable manner and the device will deliver oil to all parts involved, according to the speed of the machine or pump. Furthermore, the mechanical force feed lubricator functions only when the machine to which it is connected is in operation.

This is, of course, a direct asset for, whereas the hydrostatic or gravity lubricator requires a certain amount of readjustment to speed up the delivery of oil when machines are speeded up, the mechanical forced feed lubricator brings this about automatically.

Argument may be advanced that the mechanical force feed lubricator does not reduce labor, since a staff of operators must be maintained in any event. On the other hand, their attention can be devoted to other details of operation, since it is unnecessary for any one of them to bear in mind constantly that the lubricators may need adjustment.

This same line of reasoning holds true in the case of the external parts of engines, pumps and compressors.

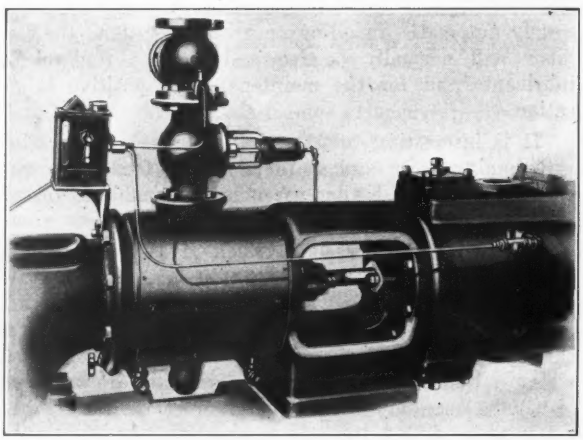


FIG. 3. FORCE FEED LUBRICATION FOR AIR COMPRESSOR CYLINDER

As a contrast to such installations, it is interesting to study certain types of boiler feed pumps, where these parts are lubricated by means of oil cups. Here it is essential for the operator to make the rounds with an oil can. This involves labor and time and may give rise to waste of oil for, normally, there will be no provision for retaining the lubricant within the clearance space involved for any great length of time. As a result, it will run into the pan below the pump or, in some cases, onto the floor of the plant.

Oil drip will lead to increased labor in cleaning up, also will involve a distinct hazard for, if oil is allowed to accumulate on the floor, the operators may slip, fall against the machinery and be seriously injured.

With automatic circulating oiling systems the construction of the base or oil reservoir of the machinery is usually oil tight. This not only prevents oil being splashed or dripped but also serves as an effective means of protecting the lubricant against the possibility of contamination by coal dust, ashes or water.

Even though advantages to be derived from automatic lubrication are obvious where equipment is not already installed, the thought may arise that the expense of discarding existing oil or grease cups will not be justified by the direct savings in labor to be obtained. These results will, however, extend beyond the matter of labor saving for, by more effective lubrication, wear will be reduced and the expense of upkeep and maintenance brought down correspondingly. In this connection, it can easily be realized that any machine out of service for bearing renewal will materially affect output, over the length of time it is out. Furthermore, the expense attendant on such work will often exceed what would have been the cost to change over the lubricating system before the trouble occurred.

### Automatic Grease Lubrication

It is well to remember that, where it is practicable to use grease as the lubricant, automatic grease lubricators are available which will require but little attention, except when they must be filled. Furthermore, by reason of the positive manner in which they deliver grease to bearings, lubrication will be effectively maintained.

There is a distinct advantage in grease lubrication for certain power plant machinery where bearing ends may be exposed, in that, by maintaining a collar of grease at the exposed ends of the bearings, abrasive foreign matter will be prevented from working its way into the clearance spaces. Such means of lubrication have been proved decidedly adaptable to stoker drives, coal pulverizers and certain other parts involved in coal handling equipment.

Protecting bearings from the entry of abrasive foreign matter is especially important wherever coal handling is involved. It is virtually impossible to eliminate all dust, or its accumulation around the moving parts. If, however, the means of lubrication have been devised to prevent the entry of such matter to the bearing surfaces, obviously their life will be much extended.

### Oil Strainers a Protection

In connection with automatic circulating oiling systems the use of strainers, as employed in the automobile engine, will save a considerable amount of labor. Where such a system can be kept clean, and the oil maintained as nearly as possible in its original state of purity by the use of proper straining devices, the oiling system will have to be cleaned out less frequently than would otherwise be necessary.

In fact, where efficient strainers are used and the entire lubricating system is sufficiently tight, it will be necessary to do cleaning or even to change the oil only at infrequent intervals. All that is required in such systems is to add a certain amount of make-up oil, according to the operating consumption of the machine.

It must be remembered, however, that strainers or other means of cleaning or purifying lubricants during service are adaptable only to oils. Greases cannot normally be treated in this manner.

### Gear Housings

Where gears are involved, labor can also be reduced by the use of proper means of housing. As a general rule, this does not have to be especially oil tight for the average gear lubricant will be of comparatively heavy body and a small amount will maintain the proper film

on the gear teeth. On the other hand, if this film is allowed to absorb abrasive foreign matter, the teeth will be worn to such an extent as ultimately to cause an abnormal amount of noise and require readjustment or replacement.

Where gear lubricants absorb dust, in the interest of protecting the tooth surfaces the contaminated lubricant should be cleaned off at frequent intervals. This will oftentimes be a hard, dirty job, requiring the shutting down of the machinery during the period of cleaning. If the entry of dust is prevented by properly enclosing the gears, this labor can be materially reduced and the periods between cleaning lengthened.

It is also interesting to note that the use of oil tight gear housings will permit the adoption of some form of automatic pressure oiling system. Where such means of lubrication can be applied, it is practicable to use a more highly refined and more fluid lubricant than the average product necessary for exposed or but partly enclosed gears. The use of this lighter viscosity oil allows a filter to be installed in the lubricating system to maintain more positively the lubricating ability.

Automatic systems of lubrication designed for gear installations may be arranged to be driven directly off the gear or pinion shaft, thus ensuring a constant stream of oil at the point of gear mesh throughout the period of operation. Furthermore, this stream of oil will start immediately with rotation of the gears.

### Location of Oil Storage

Protection of lubrication and reduction of labor can be improved by locating oil storage as close to the point of use as possible. Where lubricants must be transported over any distance, time is lost especially if a considerable volume of lubricants is to be handled.

Possibility of contamination of lubricants will also be reduced by minimum handling prior to usage. It can be readily appreciated that, if an operator must be sent across the yard for a can of oil and it is exposed in any way, there will be considerable likelihood of dust and dirt gaining entry. Any dirt which enters a lubricant will go into the lubricating system when that lubricant is used.

### Oil Handling Equipment

In connection with oil storage, it is well to stress that by the installation of suitable means for handling lubricating oils and greases, material savings in labor can be effected. Wherever possible, self-measuring or metering pumps should be installed, designed for the automatic handling of oil directly from bulk storage tanks to individual containers. They can also be equipped with suitable drains for the purpose of returning any drip or over-flow to the storage tanks before there is chance of gathering dust.

This is an item in the saving of labor around a plant for, if drip can be eliminated, the work of cleaning the oil house or storage room can be reduced.

It is an advantage to be able to handle oils by means of a pump, without the necessity for handling bulk containers. Also the self-measuring or metering oil pump assists in maintaining an accurate system of lubrication accounting. In certain plants this will be of great value in determining the amount which will probably be required over a certain period of time.

Obviously, if a comparatively large gallonage will be needed advantage can be taken of lower cost by buying in bulk. It is, however, possible to form an accurate estimate of the proper requirements only by carefully recording the amount of lubricant used on each individual machine in the plant.

## Cold Freezer Room with Welded Coils Evolved from Vacant Building

Two years ago, we had a vacant building, of concrete construction with apron walls of brick, which we wanted to convert into a meat and poultry freezer.

First it had to be cleared of all old machinery, then considerable excavating was done to make floors match. In order to use the first floor for low temperature, we made a fill under it of two feet of cinders, then laid a concrete slab 6 in. thick, then 6 in. of cork board, insulating each post and the walls from the bottom of the cinders up. Next we laid a 4-in. concrete slab on this, using wire mesh for reinforcing.

Each post was insulated 2 ft. above the floor, then a netting of fine poultry wire was tacked to the cork and a special plaster applied.

This building, of L type, was three stories high, the first floor having a ceiling height of 14 ft., the second floor 10 ft. and the third floor 12 ft. Floor measurements were 34 by 75 ft. long with the L 50 by 50 ft.

In piping these rooms, we bought plain-end pipe in random lengths, as the complete coils were welded with oxy-acetylene torch, return bends having 7-in. centers. Threads were cut only at the valves, which consisted of a ½-in. expansion valve, a 1-in. defrosting valve, and a 2-in. globe valve on the suction of each coil. All ells, tees and other fittings were made by welding pipes together, even to the suction liquor line and the hot gas line for defrosting. These lines were 250 ft. from the compressor.

For hangers for the coils, steel bars of random length were bought, bolt holes were burned in, steel was cut proper lengths and all scrap that was cut from original lengths welded together and used. So this was not only an economical job but one that will last for years. All coils were tested out under 150 lb. air pressure.

With the defrosting line, we are able to drop the frost off coils containing 3000 lineal ft. of 2-in. direct expansion pipe without the least particle of moisture on the floor and raising the temperature of the room only from the 12 deg. ordinarily carried to 16 deg. As soon as coils are again turned on, the temperature can be brought down to 12 deg. in 15 to 20 min. so the cleaning of the coils is easy.

Kansas City, Kansas. J. F. Staley.

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In the six years from 1909 to 1915, the number of customers of electric light and power companies in the United States doubled and then doubled again in the next six years, 1915 to 1921. The increase today is at the rate of about 1,500,000 new customers per year.

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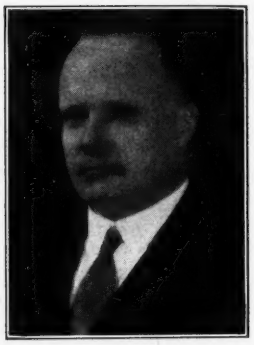
Every transformer consists of two windings on an iron core. The winding connected to the power supply is known as the primary while that connected to the load is known as the secondary.

# WELDING *IN PLANT REPAIRS*

## Use of Right Methods and Equipment by Experienced Operators Cuts Costs in Manufacture and Plant Upkeep.



By HARRY W. BENTON
Plant Engineer
Pratt and Whitney Co.

WHEN ONE SPEAKS of welding, he may have in mind any one of several methods of uniting metals. Not so many years ago, welding was almost entirely performed on the old-fashioned anvil by the village blacksmith and was quite an art.

That method of welding stands pre-eminently before all others in some respects especially for welding of links of chains used for heavy and important hoisting purposes. Machine welded and electrically welded chains are of course reliable for many purposes but when sling chain on cranes carrying heavy loads is needed, those having hammer-welded links are the most dependable.

### Requisites for Success

Success in welding for plant repairs depends first of all on the attitude of the management toward welding and secondly, upon the type of workmen and equipment employed. It is necessary to have thorough understanding of the particular application of each type of equipment. While an electric arc welding machine can satisfactorily unite the various parts of a broken casting, many casting repair jobs can be more satisfactorily performed with the oxy-acetylene torch. Also while beautiful work can be done with an oxy-acetylene torch on sheet metal, on many jobs an electric arc welder could be used to greater advantage. Evidently, welding in its broad sense should be thoroughly understood by those responsible for the work in order that the right type of equipment may be purchased and properly applied and also that each welding job be done with the equipment best suited to that particular task.

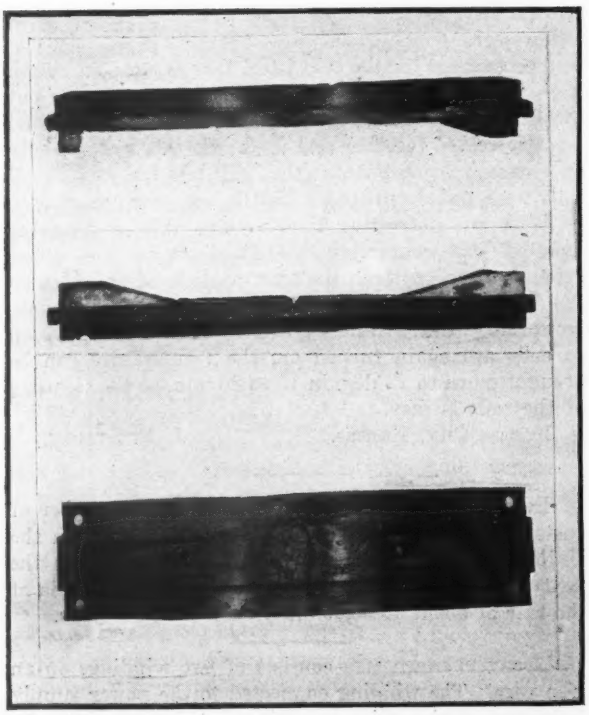


FIG. 1. CASTING READY FOR WELDING WITH SIDE AND TOP VIEWS OF COMPLETED WELD

In many establishments, welding is an operation that the superintendent has been inclined to leave to some individual workmen who has merely learned how to use a torch but has no real understanding of the principles involved further than that the heat melts the two parts together. Where welding is well managed, results prove that the user is amply compensated for time spent in studying the application and that the savings pay back the costs involved many times over.

### Welding vs. Riveting

Some three years ago, I went into a plant where the oxy-acetylene torch had been entirely discarded. The sheet metal division had to fabricate sheet steel into various forms for belt guards, trays, pans, hoods and the like, in metals varying from 16 to 10 gage. These were bent into shape by various methods and the several pieces then riveted together, giving a finished job which was a fair piece of work of its type but the time involved was too great and the finished product was not a really good-looking job.

After several weeks of persuasion and argument, an oxy-acetylene welding and cutting outfit was purchased and one of the sheet metal men given careful and detailed instruction. He evinced a desire to learn the use of the torch and developed into a good welder. After 3 yr. experience, he is producing a class of welded products thoroughly first-class, which would be pronounced by anyone a beautiful job.

We have also made use of the cutting torch to great advantage in several cases where steel structures and

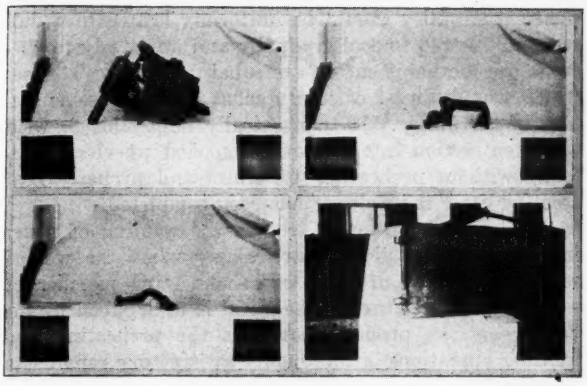


FIG. 2. EXAMPLES OF REPAIRS, A, CONTROLLER CASE. B, CORNER ON BRACKET. C, HOIST BRAKE ARM. D, HINGE LUG ON DOOR

castings had to be scrapped. It has been found remarkably effective in cutting up the metals into pieces that could be readily handled, accomplishing the work in a short time and at low cost as compared with any other method. In removing obsolete pipe lines, the pipe can be cut in suitable sections instead of having to break large fittings as was customary in the past.

For underground water line repairs we have applied the torch for burning out of the lead in bell-end joints, and found this more rapid than any other method, thus speeding up the work of repairs. Today, in this particular shop, the torch has become such a reliable, dependable tool, that it would almost stop production, if the torch were abandoned.

### Piston Break

Recently there came to my attention a break-down of a low-pressure cylinder head of a steam-driven air compressor. This had the usual Corliss type air inlet valves with poppet type discharge valves. The machine had been in operation 24 hr. a day for a considerable time, with no possible shut-down for examination and general reconditioning. One of the discharge valves on the outer end of the low-pressure air cylinder had pounded on its seat sufficiently so that the valve had dropped through into the cylinder and, when the air piston came back on its stroke, this valve was wedged between the piston and the cylinder head, wrecking the cylinder head, while the valve cut its way into the piston sufficiently to make a slot ⅜ by 2 in. through into the hollow core section of the piston.

As promptly as possible, a repair cylinder head was obtained and fitted so as to get the machine in operation but, upon putting the machine at work, a distinct blow-back was noted every time that the piston was on the end of its stroke next to the head which had been broken. This was because the core space inside the piston was connected through the slot to the clearance, increasing it by the amount of the core space. As the intake valve opened to permit the admission of air, instead of air rushing in, a blow-back actually occurred due to the discharge of air at receiver pressure from the inside of the piston, which blew out into the clearance space and through the mechanical intake valve.

A new piston would have cost approximately $100 to $125 and would have taken ten days to obtain one from the manufacturer. The compressor would have been out of service that long with delay in production or it would have been operated under the disagreeable condition of blow-back and a considerable labor charge incurred for removal of the old piston and installation of the new one. Altogether the expense would have been from $200 to $250. We used the acetylene torch and, in a short time, welded the defect satisfactorily. This unit was put in service and has been running for over a year without further difficulty, another credit mark to the use of welding in plant repairs.

### Motor Shafts and Gears

In so many ways, has the welding torch lent itself to plant repairs that illustrations could be given almost without end. A few will be of interest and will suffice.

Take electric motors of the reversing type, for example. These have driving pinions applied to the end of the shaft and keyed in position. Frequently these pinions work loose as the key-way in the shaft becomes enlarged and the sides are battered so that it is impossible to fit a new key satisfactorily into the old key-way. In such cases, it is frequently found that the side of the shaft opposite the key-way is also somewhat worn, which tends to make matters worse.

This condition can be corrected and a thoroughly first-class repair made by building up the shaft with the oxy-acetylene torch, filling in the keyway with new metal, also the worn side of the shaft. The shaft can then be turned down to size and a new keyway made, either by recutting in the old location or by cutting a new keyway at some other point. This work can be done for much less than the cost of a new shaft installation but the old pinion should be discarded and a new pinion fitted on the shaft.

When some teeth are broken from a gear, it is possible to repair it by filling in the section where the teeth are broken with new metal, building on sufficiently so that the gear can be re-machined and the welded section re-cut, thus making entirely new teeth in that section of the gear. It has been my experience that a more satisfactory result is accomplished in this way than by trying to weld in just sufficient metal for each individual tooth.

Stopping leaky joints at threaded connections in pipe

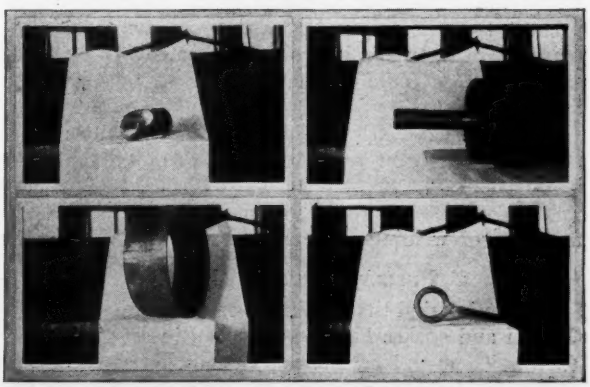


FIG. 3. TIME AND EXPENSE SAVED ON THESE JOBS. A, CAM TO BE FILLED IN AND RECUT. B, KEYWAY FILLED IN AND NEW ONE CUT. C, STEEL PLATE GEAR GUARD. D, RING END WELDED ON BAR

FIG. 4. BUTT WELDING OF PIPING, BY THOMPSON ELECTRIC CO.'S WELDER

lines is an interesting use for the welding torch. In cases where it has seemed particularly difficult to get the joint to remain perfectly leak-proof and where the expense of taking out the joint so that it could be replaced with a new threaded fitting was too great, the fitting has been welded permanently to the pipe and results have been satisfactory.

Sometimes, because of different bolt hole dimensions in pipe flanges, we have filled up the original bolt holes with new metal, faced off the metal at these welded places, then laid out a new bolt circle and drilled new bolt holes as required.

As another illustration, in the case of a duplex, steam-driven boiler feed pump, a defect developed in the dividing wall between the valve chambers, which separates the two ends of the pump, so that a part of the pump displacement merely surged back and forth through this defect. Since the hole was not large, which would have required dismantling the pump so as to preheat the whole cylinder casting, it was readily repaired with the pump in position at comparatively small expense, which could not have been done by any other method.

Some jobs, which can hardly be satisfactorily undertaken by the operators usually found in the plant, can be satisfactorily accomplished by the aid of expert welders who are available upon request to the manufacturers of welding equipment.

### Pulleys Must Be Heated

I have in mind the welding of cast-iron wheels, where the rim and spokes have been broken in several places. Such a job should be undertaken only by a person experienced in this particular class of repair because the entire wheel should be preheated and maintained at the necessary temperature during the entire time that the welding is being performed. When the welding is completed, the pulley should be uniformly heated to a dull red and allowed to cool gradually and uniformly to prevent the development of unequal shrinkage stresses which would almost certainly cause cracks in some section of the pulley. It is practically impossible to weld a broken section into a cast-iron spoked wheel satisfactorily without preheating the wheel and properly heat treating after the welding has been completed.

The same condition is true in the welding of many irregular shaped pieces, particularly when the welded section is a part of some cross-connecting member or section. If the nature of the metal is understood by the welder and he properly conducts the preheating and welding operations, a thoroughly satisfactory repair can be made.

### Use Judgment as to Repairs

Welding as performed by the oxy-acetylene torch or by the various electric process is not a cure-all and in some cases breaks should not be welded. Each case must be decided on its own merits and, if a decision is made by a man who has a knowledge of welding principles and processes and a background of welding experience, results will be satisfactory. If the experience of the welder in any particular plant is insufficient so that he is unqualified to pass judgment on the welding of some important casting or broken machinery, the management should call in the services of a welding expert from the manufacturers of welding equipment, to outline the proper method of procedure or make the weld.

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Lightning missionaries, men who go afield to study the vagaries of thunderbolts from the skies and record these phenomena in the form of permanent records, are an important part of electrical research. At the present time there are two such groups from the Pittsfield, Mass. works of the General Electric Co. now in distant places, watching and waiting for the thunder storms which give them much in the way of engineering. These keen minded men do more than watch and wait. When things are dull in the natural lightning line, they get busy and make a little for themselves. Each group is equipped with an impulse generator that will produce from a million to a million and a half volts of artificial lightning.

One of these modern missionary groups is now in Michigan. An all-summer program is planned along a 50-mi. transmission line of the Consumers Power Company. The second group, to be on location in Ohio, will work on a 132,000-v. transmission line of the Penn-Ohio Power Co. between Philo and Canton, Ohio.

In addition to the impulse generators, each party is equipped with newly developed, portable cathode-ray oscillographs. These delicate recording instruments are mounted in complete laboratories by themselves, on automobile truck chassis. They are the means through which permanent records are obtained on photographic film of the passage of lightning bolts, either natural or artificial.

All of these studies are being undertaken by the General Electric Co. in cooperation with other concerns for the basic purpose of improving designs in apparatus.

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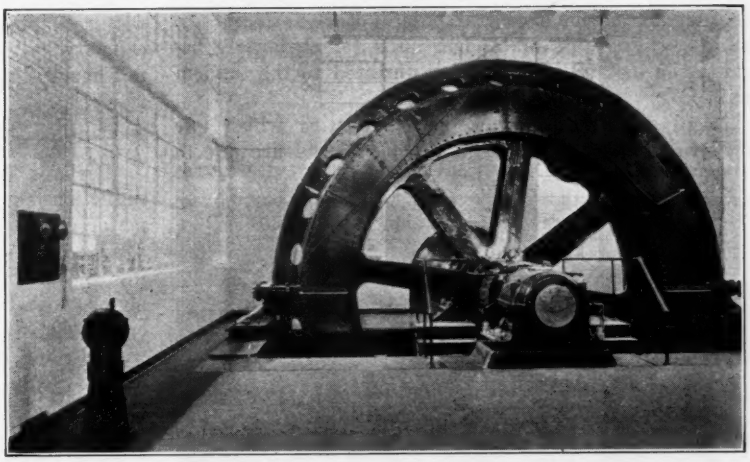
Steam accumulators have been successfully applied to central station practice in Germany.

# MOTOR DRIVE FOR HEAVY LOADS

By R. H. WRIGHT*

INDUCTION MOTOR FOR ROLLING MILL DRIVE. 5000 HP. 13,200 VOLTS. 60 CYCLES. 99 R.P.M. METHODS OF CONTROL. APPLICATION OF SYNCHRONOUS MOTORS



IT IS WELL KNOWN that for years American industry has been busily engaged in taking out line shafts and replacing the engines or motors by which they were driven with large numbers of comparatively small motors, each directly coupled to an individual machine or a part of a machine. As a result, the average horsepower per motor installed in a given year is quite low.

While the machine tool and light machinery builders have been improving their machines by the application of more and smaller motors with special characteristics, the users and builders of heavy machinery have been designing heavier machines requiring increasingly larger motors. For example, the first rolling mill in this country to be electrically driven has two 1500-hp. motors; while the heaviest mills now being built use 10,000 hp. to drive a single pair of rolls. In the rolling mills of this country there are now installed or building nearly two thousand motors of 300 hp. or more capacity, with a total aggregate capacity of two million horsepower. It is interesting to note that 90 per cent of these motors were installed after January 1, 1915, and 65 per cent of the installations have been made in the last ten years.

## MILL ARRANGEMENT SHOULD TAKE ADVANTAGE OF MOTOR-DRIVE POSSIBILITIES

Until a few years ago, hot rolling of strip was done at slow speed and the steel was dragged about by hand over an iron floor and passed by hand from one set of rolls to another. The rolls were connected together in groups; each group being driven by a motor or an engine. The steel cooled rapidly on account of its contact with the floor and the cooling, together with the slow speed of the rolls, limited the reduction which could be made in the thickness of the metal and definitely fixed the minimum thickness to which the strip could be rolled. The temperature at which the steel was delivered from the mill varied with the skill and luck of the men who handled the strip between passes. Variations in the finishing temperature affect the thickness of the finished material, thus making it difficult to roll to uniform thickness.

Disadvantages of the hand mill were eliminated by arranging the roll stands in tandem, with the stands mounted on close centers so that metal passed quickly and automatically from one pair of rolls to another.

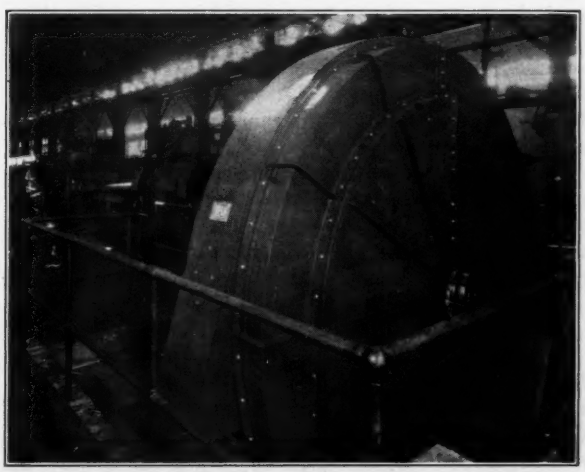


FIG. 1. SYNCHRONOUS MOTOR WHICH STALLS ONLY AT 350 PER CENT OF RATING, 1800 HP, AT 6600 V. AND 150 R.P.M.

*Steel Mill Engineer, Westinghouse Elec. & Mfg. Co.

The speed of the rolls was greatly increased, thus increasing the output. The hard and dangerous labor of handling the hot steel between stands was eliminated. Thinner material could be rolled and variations in finished thickness were practically eliminated.

Advent of the high-speed tandem rolling mill has revolutionized the production of a number of important steel products. This type of mill has been made possible through the use of individual motor drive for each roll stand. The motors employed are adjustable-speed, direct-current type, designed to have fine speed regulation and with control arranged so that all motors can be regulated from a central point. Early attempts to build certain types of tandem mills failed, largely because the method of drive was unsuited to the tandem mill.

And so the speed and accuracy with which our modern industrial operations are performed are due to

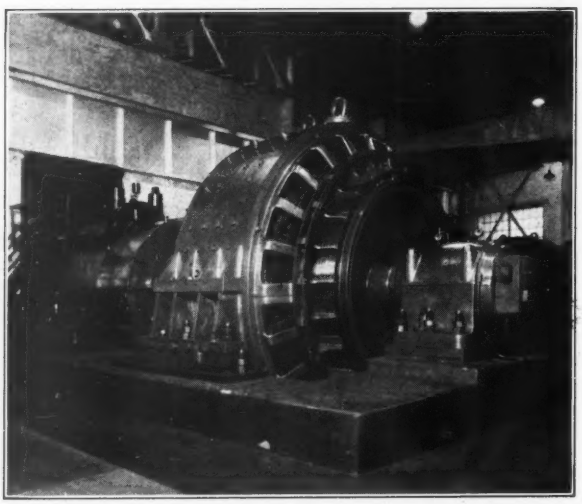


FIG. 2. 7000-HP. D.C. REVERSING MOTOR FOR 700 V. MAXIMUM TORQUE 2,000,000 LB. FT.

the use of plant equipment which has been designed to utilize the best performance characteristics of electric drive. The drive is no longer looked upon as a thing apart from the machine but rather as a part which has a vital effect on the performance of the machine. The electrical efficiency is not a major consideration in the selection of the electrical equipment because, by sacrificing electrical efficiency, the output of a machine may be greatly increased. For example, the direct-current motor usually is not as efficient as an alternating-current motor and the losses in the converting equipment are considerable. But the greater flexibility of operation obtained through the use of adjustable-speed, direct-current motors often more than justifies the slightly increased power consumption.

### Types of Heavy-Drive Motors

Because of the great amount of power used by the larger industrial plants, the main distribution circuits are three-phase, alternating current, usually 6600 v. and occasionally 11,000 or 13,200 v. For heavy-duty, constant-speed drives, wound-rotor induction motors or synchronous motors, designed to operate at the plant line voltage, are applied. The wound-rotor motor came into general use for rolling mill and other heavy service before the synchronous motor was seriously considered, units up to 7000 hp., having been installed as early as 1917. Large synchronous motors have been applied extensively only during the last five years.

Early popularity of the wound-rotor induction motor was due to its ability to start heavy loads without drawing heavy currents from the power system and because the induction motor can be operated in conjunction with a flywheel in such a manner that heavy intermittent load peaks will be equalized, reducing line disturbances to a minimum. When power systems were small, these features were important but, with the present large capacity systems, moderate intermittent load peaks are not harmful and synchronous motors can be used more freely.

### Flywheel Action for Sudden Peak Loads

Perhaps the best modern example of a combination induction motor and flywheel application is the flywheel motor generator which supplies direct-current power to a large reversing mill motor. A modern 7000-hp. reversing blooming mill motor receives its power from a motor-generator consisting of two 3000-kw., 700-v. generators, a 50-t. steel plate flywheel and a 5000-hp., wound-rotor induction motor. A liquid slip regulator automatically varies the resistance in the secondary winding of the induction motor and limits the power peaks drawn from the line to a predetermined value, usually about the full load input of the motor. The 7000-hp. reversing motor is designed to withstand momentary peaks up to 19,000 hp. and its normal operating load consists of a series of sharp peaks.

Sudden application of a 19,000-hp. load on the reversing motor is instantly reflected back to the motor generator and the load on the 5000-hp. induction motor begins to increase. When the load on the induction motor reaches the value for which the load regulator is set, the regulator instantly operates to increase the motor secondary resistance, which action causes the induction motor to have a tendency to slow down. As the motor-generator slows down, the flywheel gives us sufficient stored energy to equalize the peak.

During the period of no load which follows the peak on the reversing motor, the motor-generator is gradually brought up to speed and energy is restored to the flywheel so that it can supply energy to equalize subsequent peaks. The use of flywheels is usually limited to applications where the load is highly fluctuating and where the peaks vary from a fraction of a second to 5 seconds in duration.

### Synchronous Motor Application

Large synchronous motors are used where the starting torque is moderate and for applications where the load is either fairly steady or consists of a succession of peaks of such long duration that flywheels cannot be used to advantage to equalize the load. The starting current for a given starting torque is much higher than with a wound-rotor induction motor. A high-speed synchronous motor of normal design will have a starting inrush of four or five times the normal full load kilovolt-ampere input, when started at full voltage, and the starting torque will be approximately 150 per cent of full load torque. The full-voltage starting inrush of a

slow-speed motor will usually be between three and four times the rated kilovolt-amperes and the starting torque will be somewhat lower than for a high-speed motor.

Special starting windings are sometimes used, which give starting characteristics similar to those of an induction motor. At reduced voltage the starting kilovolt-amperes and starting torque are reduced both being proportional to the square of the voltage applied. Motors of 5000-hp. capacity have been built for starting by means of reactors connected in the neutral of the primary winding and one motor of 8500 hp. is being built for starting in this manner.

Synchronous motors can be designed for very heavy overload capacity. For example, in a seamless tube plant, the mills which pierce the heated steel billets may have peak loads up to 350 per cent of the average load. The time to form a rough tube in the piercing mill may vary from ten to 20 sec., which is too long to make a flywheel of any benefit in equalizing the load. Synchronous motors, designed for a stalling torque of 3½ times normal rated torque are applied. Motors for large piercing mills usually have a normal continuous rating of from 2000 to 3000 hp. with stalling torques corresponding to from 7000 to 10,500 hp.

On account of the poor power factor of the slow-speed induction motor, high-speed, geared induction motors have been used in many cases in the past. The modern synchronous motor frequently compares favorably in cost with a geared drive, besides offering the advantage of a direct drive and the possibility of obtaining any desired power factor.

### Adjustable Speed Service

For adjustable speed service, the simplest type of motor is the direct-current. It is, however, sometimes desirable to have a heavy-duty, adjustable-speed drive where direct-current power is unavailable and where it is undesirable to install the necessary converting equipment to supply direct current. In such cases, a wound-rotor induction motor, with special speed regulating equipment connected in the secondary circuit is used. Such equipments can be built either for constant horsepower output or for constant torque with varying horsepower output.

Constant-horsepower, alternating-current, adjustable-speed drives usually consist of a standard, wound-rotor induction motor to which a standard direct-current motor is coupled. The secondary winding of the induction motor is electrically connected to the alternating-current side of a standard rotary converter. The direct-current side of the converter is connected electrically to the direct-current motor, the speed of the set being adjusted by varying the excitation of the direct-current motor by means of an ordinary rheostat. Adjustable speed equipments of this type operate only below the synchronous speed of the induction motor. They are economical to build for speed ranges up to 2 to 1. The chief advantage of this, known as the rotary converter or Kraemer system, is its simplicity. The Kraemer system can also be used for constant-torque drives by connecting the direct-current end of the rotary converter to the direct-current machine of an inverted motor-generator. Kraemer drives up to 7500 hp. capacity are in operation in this country.

Constant-torque, adjustable-speed sets are usually designed to operate both above and below the synchronous speed of the induction motor, the maximum practicable adjustment being usually limited to 30 per cent on either side of synchronous. In some cases the regulating equipment consists of a regulating set having a special commutator-type regulating machine and an induction motor together with the necessary alternating-current exciter and regulating transformer. The speed is adjusted by changing taps on a transformer. In some cases the regulating machine can be mechanically connected to the main induction motor. Double-range, alternating-current, adjustable-speed drives in capacities up to 6700 hp. are in use in rolling mills and up to 28,000 hp. on variable-ratio frequency changers.

### Reversible Drives

Large direct-current motors are used principally for heavy duty reversing service and for adjustable speed

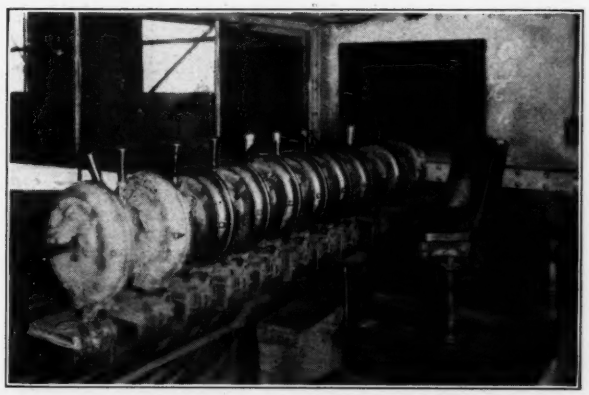


FIG. 3. CONTROLS FOR 7000-HP. REVERSING MOTOR. FOOT MASTER SWITCH FOR MAIN CONTROL, HAND SWITCHES FOR SETTING MILL ROLLS AND FOR MOVING AND TURNING INGOT

drives where accurate, wide range speed control is required. Reversing motors are applied almost exclusively to heavy duty rolling mills and to high-speed mine hoists. The largest reversing motor built to date in this country is rated 8000 hp., 40 to 80 r.p.m., 700 v. This motor drives a 54-in. blooming mill in which steel ingots weighing up to 40,000 lb. are rapidly rolled down to rough beam blanks. It can exert a maximum torque of 3,000,000 lb-ft. A similar mill is now under construction which will be driven by two 5000-hp., 40 to 80-r.p.m. motors, one motor connected directly to each roll, thus eliminating the pinions required for a single motor drive. Power will be supplied from a 9000-kw., 700-v. flywheel motor-generator. Even the most powerful reversing motors are controlled by small foot pedals, while the motor operator at the same time controls other operations with his hands.

Non-reversing, adjustable-speed, direct-current motors have the greatest field of usefulness where flexibility and accuracy of control are required, as in the case of the tandem strip mill mentioned previously. For many applications where operations must be synchronized closely, motors can be designed to have inherent characteristics which will make them suitable for the application. Where extreme accuracy is required, special speed-regulating equipment is used.

## Cutting Roofing Paper in Large Quantities

On a contract involving the installation of 78,000 lineal feet of tunnel piping the specifications called for the pipe insulation to be covered with two-ply waterproof roofing paper, secured in place by turns of copper wire. The cutting of the paper in varied lengths to suit the different pipe sizes meant an appreciable labor item.

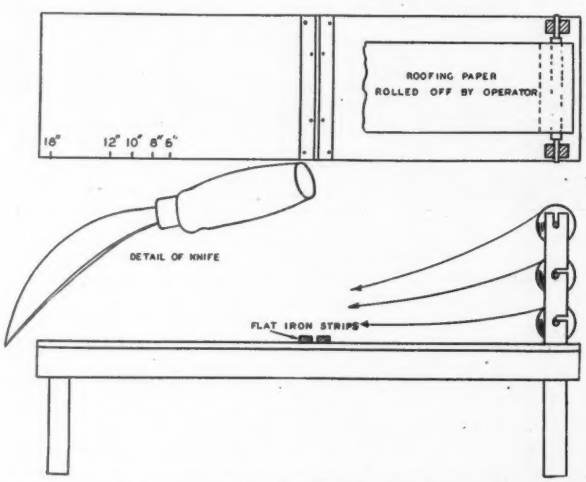



TABLE AND KNIFE FOR CUTTING ROOFING PAPER IN LARGE QUANTITIES

We hit on the method explained and sketched here as the most efficient way of doing the work.

Uprights fastened to one end of a long wooden table, carried three steel rods bearing pipe sleeves which supported rolls of roofing paper so that the latter could be readily drawn off by hand. Two strips of flat iron were fastened with flat head screws near the middle of the table in a position parallel to the rolls. They were placed ¼ in. apart.

Along the top edge of the table heavy pencil lines were made at various distances from the quarter inch slot, corresponding with the lengths of paper to be cut. Each line was marked with the pipe size for which the paper was intended, as 6 in., 8 in., 10 in.

Three lengths of one size were cut at a time. The operator held together the projecting ends of three rolls of roofing paper, pulled this common end to the line indicating the size desired and cut off the correct length by drawing his knife across the slot between the two pieces of flat iron.

A curved knife sharpened on the concave side was used. The men employed on the operation soon became very proficient in the work. We believe our improvised cutting table reduced to a minimum the labor cost for this work.

Wassaic, N. Y. Theron W. Bean.

## Collection Troubles at Slip Rings

Slip ring wear of revolving armature alternators and rotary converters arises from three causes, mechanical abrasion, a burning action and a quasi electrolytic effect.

The wear due to mechanical abrasion depends on the number of brushes used, their type and the pressure with which they bear on the slip rings. This wear will be uniform all round the ring and can be kept reasonably low by properly selecting and fitting the brushes. The wear due to the burning action is largely connected with the current density in the brush, if the current density is so high as to cause severe heating at the point of contact the wear due to the burning action may be considerable. The wear due to the quasi electrolytic effect arises because of the gradual transference of the ring metal in the direction of the current flow. This causes the ring where the current flows from the ring to the brush to be worn bright, while that ring where the current flows from the brush to the ring assumes a dark color.

Wear on the ring worn bright will be many times greater than on the other ring and, in some cases, in order to equalize the wear, the connections to the rings are reversed periodically which reverses the current flow from the rings to the brushes. The wear due to both a burning action and a quasi electrolytic effect are not uniform all round the ring, but will only occur during the half cycle when the current flows from the ring to the brush. This has a tendency to cause flats to form round the ring, especially if the number of brushes employed is small.

Wear due to this effect can always be reduced by increasing the number of brushes round the ring, this will reduce the current per brush and as the current is collected at more places round the ring the wear will be more uniformly distributed.

For instance, if the number of brushes is doubled,

the current per brush is halved and the places where the current is collected is doubled, this leading to a considerable evening of the wear round the rings.

In many of the high speed turbine alternators instead of having the usual bronze slip rings, are equipped with steel rings. While these rings have great strength, they have the disadvantages of having a much lower thermal conductivity than bronze and the contact drop is some 30 per cent greater than with bronze rings. They also tarnish rapidly and this increases the contact drop. These disadvantages cause the formation of flats. This tendency is increased owing to the fact that the tarnish is not uniformly distributed round the rings. The rings tarnish when the machine is at rest, but as parts of the ring are then covered by the brushes, the portion of the ring covered by the brushes will not tarnish. A ring in this condition will be conducive to the formation of flats, owing to the unequal resistance of the ring at different points round its circumference.

Tarnishing can be largely prevented by wiping the rings with a rag moistened with paraffin as the machine comes to rest. This will form a film on the ring which will protect it from the atmosphere.

London, England W. E. WARNER.

## Torch Aids in Bending Pipe

PREVALENCE OF WELDING and its attendant advantages has reduced somewhat the amount of detail necessary in laying out the piping on the drafting board. The number of factory bends necessary has been greatly reduced because the smaller ones can be made in the field by the welders in a comparatively inexpensive manner. The following is a method of bending steel pipe that has proven satisfactory.

Heat the pipe to be bent with the torch at the point where the bend is wanted. Then drop a few drops of water on the inside of the bend, keeping the pipe hot with the torch as the water is dropped. It takes an experienced man about half an hour to bend a 4-in. pipe.

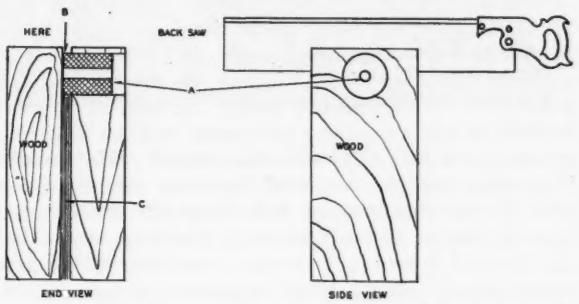
As a rule, 4-in. pipe is about the largest that can be bent economically; for pipe of 6 in. and over, factory bends are cheaper. The exact economic size depends upon local conditions of freight and transportation as well as on the bending skill of the welder. No equipment of a special nature is required and time is the only element of cost. When considering the element of cost it must be remembered that the field made bends cut the preliminary engineering work a great deal by reducing elaborate engineering layouts while the cost of the field bends may be more than the labor charge of the welders because they may hold up other members of the crew.

Springfield, O. F. PAUL.

## Worn Pump Valves Refaced by Saw

REFACING WORN pump valves may be easily done and at practically no cost by the use of the wooden clamps illustrated. One of two pieces of wood 2 in. thicker and several inches wider than the pump discs that are to be refaced, is bored at one end with a hole slightly larger in diameter than the valve disc and about $\frac{1}{16}$ in. less in depth than the thickness of the valve disc.

The valve is placed in the hole with the side that is to be refaced on the outside as shown. The other piece of wood is then placed against the slightly projecting valve disc and a piece of cardboard placed between the two pieces of wood at, C, in order to keep the faces of the wood blocks parallel. By clamping the two pieces of wood in a vice the valve disc will be held firmly.




HOW A BACK SAW CAN BE USED TO REFACE A WORN PUMP VALVE

With a fine toothed back saw, placed in the groove at B, the defective portion of the disc may be sawed off without difficulty, the carboard preventing the saw blade from binding and the two pieces of wood guiding the blade so that a proper surface is secured.

If one cut is not sufficient, place a disc of cardboard in the hole under the valve disc and saw it again as before. Roughness of the surface may be easily removed by rubbing the valve disc on a piece of sandpaper which has been laid upon a flat surface. If a fine saw is used, little subsequent smoothing will be required.

Lakeview, Ont. JAMES E. NOBLE.

## Dustless Removal of Plaster Wall

HAVING OCCASION to tear a partition wall in our plant recently, we were assured solemnly that it would take two weeks to accomplish and that it would fill the place so full of dust that the plant would have to shut down. The wall was of plaster on wire lath and the job looked formidable.

After the following method of performing the task had been developed, the actual work became simple and quite easy. The plaster was first scored across the wall exposing the metal lath on both sides, horizontally and vertically on 3-ft. centers. This lath was then cut out by a torch so that the partition came down in 3-ft. square sections which were about as large as could be handled conveniently. Very little dust was made in the scoring process and practically none in removing the sections after they had been burned out.

Watertown, Mass. THOS. T. WALSH.

## Belting and Gasoline Engine Flywheels

NOT LONG AGO, I was approached concerning the proper belt to use on a gasoline engine which fluctuated badly. I was told that belts on the engine lasted only about a month and the owner was getting tired of the expense. His conclusion was that all belts are no good and so he wanted to eliminate belting entirely.

In my report, I told the owner that the trouble lay entirely in the flywheel which was not heavy enough and not at all in the belt. A correctly designed gasoline engine will have a flywheel of such size that there will be no violent fluctuations. The governor should

be sensitive enough to function properly with the flywheel and maintain a nearly constant speed.

When gasoline engines were introduced, they were crude. With every explosion, there was a corresponding brightening of the lights hence they were not satisfactory for electric lighting purposes. My brother told me of stopping overnight in the hotel of a small town in South Dakota several years ago. He noticed a periodic flickering of the electric lights. It wasn't a noisy town, so he presently heard the exhaust of what he learned was a producer gas engine and the flickering synchronized perfectly with the exhaust. He thought it strange that the people of the town would put up with the nuisance, but they did. They probably believed that all electric lights flickered in the same way. Had the flywheel been heavy enough, however and the governor delicate enough, there would have been no flicker.

Small gasoline engine driven farm electric lighting sets of today give a perfectly steady light. The flywheels are now made heavy enough and the governor sensitive enough to care for all conditions. The gasoline engine first mentioned in this article drives a reciprocating pump. What could be worse than that—a fluctuating driver operating a fluctuating driven machine? The driver has a peak impulse with each explosion and the driven machine a peak load with each discharge. Every once in a while, the two peaks coincide and unless the flywheels are heavy enough to take care of the energy, the belt will get an excessive pull and will slip, run off, or even break. When faults of design are remedied, it is invariably proven that a high quality belt of sufficient width and proper thickness will give no trouble.

Newark, N. J. WM. FRANK.

## Discarded Rubber Belting Makes Good Sign

A FAIRLY LARGE flexible warning sign was wanted temporarily near a plant for outside drivers who often made a shortcut through an area in which they had no

FIG. 1. FLEXIBLE SIGN MADE OF DISCARDED RUBBER BELTING

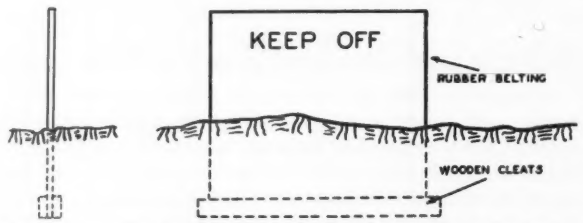



FIG. 2. PROFILE SKETCH OF SIGN SHOWING HOW IT IS HELD IN THE GROUND

business. An old piece of discarded rubber belting was procured and one made roughly as shown in Fig. 1. About a foot of it was buried under the ground, being held and steadied by two wooden cleats in the manner shown in Fig. 2. It displayed the ability of a bantam prizefighter in getting up after knockdowns during its period of use.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

## Gas Proof Joints in Ash Pits

WHEN MAKING repairs on ash pits constructed of cast-iron plates or built up of heavy sheet-iron or steel plates, it is often difficult to make the joints gas and dust-tight. The writer has tried out numerous schemes, most of them practically worthless and found the best results to be secured by making "rust joints."

Our ash receivers, on one particular installation, were built under the boilers by the use of cast-iron plates bolted together at the edges and supported by angle irons and I-beams. When any portion of the hoppers are removed for repairs, it is the duty of one of the helpers thoroughly to clean all the edges of the castings and prepare the mixture used for making the rust joints when the parts are again assembled. This rust mixture is composed of

30 parts fine cast-iron filings
2 parts sal ammoniac
1 part pulverized sulphur
1 part Portland cement

A solution of one part of sal ammoniac to six parts of water is used to moisten the dry ingredients listed above, only a small portion being dampened at a time as it is needed, because the mixture hardens rapidly. As each casting is ready to be replaced in the ash hopper, the edges are coated with a thin layer of the compound and it is then bolted into place. The joint soon sets up and stay tight almost indefinitely. Others will no doubt find this mixture useful around boilers and ash hoppers.

Cold Spring, Minn. CHAS. A. PETERSON.

## Coating Cold Water Pipes

EVERY ENGINEER should know that it is necessary to have cold water pipes dry before painting them but something else is necessary on black iron pipes if a permanent job is desired.

A few months after black iron untreated pipe carrying cold water is painted, rust will begin to show through the paint in locations where the cold water pipe passes through warm rooms. The rust spots will increase until the pipe will be more unsightly than if it had never been painted.

Prevention of this rust formation is easily accomplished, however. After closing off the flow of cold water through the pipes long enough to allow any condensation on their surface to dry, give all the dry pipes a coat of shellac. After the shellac has dried, finish the work with a coat of waterproof paint of the color desired.

Of course, if it is possible to empty the cold water pipes at the start, any moisture on the surface will dry off in a few minutes in warm locations.

Toronto, Ont. JOHN THORN.

## Power Required by Brine Circulating Pump

In referring to the calculations on page 1319 of the Dec. 1, 1929 issue recently, it appeared to me that the 20 lb. per sq. in. total head had not been converted into feet head.

The question was, what horsepower is required to operate the brine circulating pump, which has an efficiency of 80 per cent and which pumps against a total head of 20 lb. in a central brine cooling system having a total refrigeration load of 25 t., the brine being cooled in a shell and tube type brine cooler, entering at 8 deg. and leaving at 4? The specific gravity of the calcium brine is 1.218.

The computation should have been as follows:

Since 25 t. of refrigeration is required, then $25 \times 200 = 5000$ B.t.u. per min. will be required, since, for each ton of refrigeration, 200 B.t.u. must be removed per min. Calcium chloride brine of 1.218 specific gravity has a specific heat of 0.7025 per lb. If the temperature changes 4 deg. each time it goes through the cooler, it will carry $4 \times 0.7025$ or 2.81 B.t.u. per lb. pumped.

Since it is necessary to carry 5000 B.t.u. per min., it will require $5000 \div 2.81 = 1780$ lb. of calcium chloride to be circulated per min. Each pound must be pumped against a 20-lb. head which must be put in terms of feet-head by multiplying by 2.3, which is the ratio of head of water in feet to that in pounds. We then have:

$$1780 \times 20 \times (2.3 \div 1.218) = 67{,}500 \text{ ft.-lb.}$$

At 80 per cent efficiency, we should have $67{,}500 \div 0.80 = 84{,}500$ ft.-lb. and $84{,}500 \div 33{,}000 = 2.56$ hp. which is the power required.

Los Angeles, Calif. A. C. Bullen.

## Ammonia Storage

Please tell me what would happen if ammonia were stored in a very hot room.

2. If a drum of ammonia should receive a hard blow what would happen?

3. What trouble would occur if your refrigerating system should have too great a charge of ammonia?

M. J. W.

A. Ammonia is not easily explosive although it will burn readily and can be exploded under very high temperature conditions but temperatures such as may be possible in a room would hardly have any serious effect upon the contents of the drum.

Normally, the pressure in a cylinder full of ammonia is from 100 to 125 lb. At 90 deg. temperature, this pressure would rise to about 170 lb. Cylinders used for ammonia, however, are tested to 1000 lb. press. per sq. in. so they are amply strong to withstand any pressure due to normal rise in temperature. If, however, there are any valve leaks, increase in pressure will increase the leak.

2. Ammonia cannot be exploded by detonation; hence any blow, however hard, would have no effect upon its explosibility.

If the blow were so hard, however, as to damage the cylinder so that a seam is opened up, a hole punctured or that the valve is damaged, leaks would obviously occur. The valve, however, is protected against damage in ordinary handling, by a heavy cap.

3. More trouble occurs from too little than from too much ammonia in the system. Probably ninety per cent of refrigerating plants suffer from too small a charge of ammonia.

If too much ammonia has been charged, the surplus after expansion would simply go back to the compressor cylinder and increase the discharge pressure. This condition would also probably bring about stuffing-box leaks and cause the compressor valves to hammer.

## Steam Regulation During Boiler Standby Periods

I fire two horizontal return-tubular heating boilers of approximately 100 hp. each. On closing down each day, I leave the main stop valves, which are located between the boilers and the heating system, open. I fill in enough make-up water to take care of the evaporation while the remaining fire is burning out and the brick work is cooling off.

An engineer friend of mine who has had years of experience, insists that I should close the main stop valve on the boilers when closing down and prevent the evaporation taking place from the brickwork and the remaining fire from passing out of the boilers. He insists that it is safer to close off the steam outlet and let the pressure build up and pop off than to take chances on the water evaporating below the top of the tubes.

I would greatly appreciate knowing the correct procedure in this case. D. C. G.

A. The proper and safer method is the one you are following and we would advise you to continue following it.

By closing the main stop valve and keeping it closed until you had built up your pressure in the morning to normal running condition, you would be able to secure this pressure quicker; but on admitting this to the line, there is likelihood of doing so too quickly, endangering the heating system due to the sudden change in temperature and possibly causing leaks.

# Editorial Comment

## Economics, Politics, Engineering and Business

In a recent address delivered upon the occasion of the sixty-second anniversary of the University of California, Owen D. Young, in masterly fashion, painted the importance of economics in the stability of world affairs. As chairman of that great international committee which bears his name, no one is better qualified to speak on this subject and his picture of the struggle between politics and economics for supremacy in world affairs is one which is useful in fields other than that of international intercourse. For Mr. Young shows in figures, clear and unmistakable, that regardless of how dramatic and charming may be the role of politics—regardless of how she may fascinate by her appeal to our emotions, her grand manner and idealistic purposes are for naught unless she plays the game according to the inviolable rules set forth by her less charming but more rational sister called economics.

After the war, in the full radiance of the footlights, Politics received the applause of the world. In the words of Mr. Young: "What high hopes we had of her! One day she spoke through Woodrow Wilson and the audience sat breathless, moved by the high idealism of a great man and the rich expression of a master. Another day she was hard and cynical as she spoke through Clemenceau and still another time she had the delightful abandon of a mischievous mistress as she was impersonated by Lloyd George." And so she (Politics) wrote a treaty in which all the world was lost in admiration of her daring.

"True," said Mr. Young, "occasionally we heard the meek voice of Economics modestly protesting here and there, occasionally offering advice, only to be silenced by an imperious gesture of the leading lady. And then one day she decided that Germany was to pay 132,000,000,000 marks and then indeed it was time for Economics to speak, and she did, in protest. But again she was silenced. Had not Politics always been mistress of Versailles? Had not Economics always been a scullery maid? Why listen to her? And they didn't."

But it was not so easy as Politics made it out to be, and as time went on the world learned once again that Politics, with her appeal to the emotions, can easily start things in the field of economics which she cannot stop. Germany would not pay and so France decided to make Germany pay by moving her armies into the Ruhr to compel the production of coal and goods for reparation account. But it turned out that the sword was a poor instrument with which to get economic results.

And so it happened on the 14th of January, 1924, that the Dawes Committee convened in Paris, and then for the first time Economics got a hearing. The Dawes plan was no more than an interval receivership plan, but it was effective because it was based on sound economic principles. And the world learned its first great lesson —that economics does not function under political threats or military coercion.

So on October 20, 1928, Economics was again called by Politics (Politics was now quite meek) in the form of an experts committee to make proposals for a complete and final settlement of the reparation problem. This committee met in February, 1929, and on June 7 signed and transmitted its report—known popularly as the Young plan.

It may be somewhat of a presumption to attempt a comparison of a problem so vast and all important as that of the economic stability of the world, or at least that of Europe, with that of the operation of a power plant or a power system, but we wish to point out that the factor which guarantees the success of one also holds for the other. It may be spectacular and appeal to the emotions to build elaborate plants and systems, utilizing all the latest devices and principles known to engineering science but unless these devices and principles are coördinated so that their combined effect insures a commensurate return on the investment, the price paid for admission to the show may be too high. And the same is true of business in general, the electric light and power business included. It is all well and good to map out elaborate and spectacular sales campaigns, figuring years in advance what the buying power of the nation will be—how many lamps and flat irons and toasters and how many kilowatts of energy each consumer should use and then make plans for supplying the demands accordingly, but unless "Economics" is given an opportunity to present her views as to wiseness of such campaigns, by her absence she may put a stop to operations before the game is well under way. Lately there has been much loose estimating and predicting based apparently more upon the so-called science of astrology than upon economic facts. It may appear profitable to a manufacturer to schedule high manufacturing programs on the basis that each consumer should have two automobiles or two toasters or six floor lamps and an electric range in place of the two lamps and the single gas range he now has but unless the financial status of the consumer is such as to buy these things or unless there is a distinct advantage in buying them, the manufacturer may find himself in the red before long.

Whether considered in relation to politics, engineering or business, economics, in the final analysis, is always the dictator.

## Diesel Operation Justifies Expert Supervision

Some time ago a main bearing liner on a Diesel engine became badly scored. A new one was ordered and installed under the direct supervision of the chief operating engineer. After placing the liner, the shaft was inserted, the bearing tightened and the engine started up. The rapid heating of the bearing after in-

stallation puzzled the chief. Only after a service man had been sent by the manufacturer was it discovered that the new liner had not been scraped in, hence the shaft had been distorted when the bearing was tightened.

Apparently, the chief lacked that training as a general mechanic which is so essential to the operation of any power plant. Moreover, although he had assistants under him who knew that the bearing should have been scraped in, none of them advanced any information regarding this requirement, thus indicating a lack of coöperation which was due to a dominant and self sufficient attitude on the part of the chief toward his subordinates.

Although almost anyone can operate a Diesel plant, only those who are properly instructed and trained, not only in the technic of Diesel operation, but in good mechanical and electrical practice should be permitted to do so. More and more are precision methods of manufacture being adopted to the manufacture of Diesel engines. They should be accorded the same care that any fine machine should receive. The original scoring of the bearing indicated gross carelessness; the installation of the bearing liner without scraping it in showed a lack of knowledge of fundamental machine practice.

Unfortunately the Diesel engine is frequently called upon to suffer such maltreatment. It is astonishing that many so treated survive. Steam plants are considerably protected by the requirement of engineer's license although this license was required primarily to protect the public against boiler explosion. Such protection is not required in a Diesel system but would not that system be benefited if a controlled method of selection of operators, similar to the licensing of steam plant operators, were established?

Until a more reliable method of selecting Diesel operators has been established would it not be advantageous, on the part of the manufacturer, to send with the shipment ample instructions for installing a replacement part? It may not be possible to force an installing operator to read instructions but, at least, he would have before him all necessary data.

## Dynamic Aspect of Standardization

Standardization is one of our national characteristics. Some have felt we have gone too far in this matter; few realize the enormous benefits that have been derived through its exercise.

Standardization enables buyer and seller to speak the same language and makes it possible to compel competitive sellers to do likewise. In thus putting tenders on an easily comparable basis, it promotes fairness in competition, both in domestic and foreign trade.

It lowers unit costs to the public by making mass production possible, as has been so strikingly shown in the case of incandescent lamps and automobiles. By simplifying the carrying of stocks, it speeds deliveries and lowers prices. It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public.

It stabilizes production and employment by broadening the possible market and by making it safe for the manufacturer to accumulate stock during periods of slack orders to an extent which would not be safe with an unstandardized product thus evening off the fluctuations of seasonal employment. It makes possible the high standard of living enjoyed by even our so called laboring class. By focusing on essentials, it decreases selling expense. By concentrating on fewer lines it enables more thought and energy to be put into designs so that they will be more efficient and economical.

By bringing out the need of new facts in order to determine what is best and by securing agreement on most questions, the American Standards Association acts as a powerful stimulus to research and development. It is one of the principal means of getting the results of research and development into actual use in industry.

Standardization helps to eliminate practices which are the result of accident or tradition and which impede development. By concentration on essentials and by consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely on efficiency in production and distribution and on intrinsic merit of product.

Due to the coöperative spirit existing among the power companies throughout the country, many standards have been adopted in this field, the vast majority of which have dealt with physical dimensions and chemical constituents which have been demanded of manufacturers in order to cut down not only initial costs but maintenance and repair costs and to insure safety to attendants. The adoption of such standards have been influential in bringing down costs of generating power in spite of increasing cost of labor and fuel. It is hoped that the example set and demonstrated by the engineering departments along the line of standardization will be emulated by the business departments in reducing the distribution costs of electric power which have recently been severely criticized by the public press.

## Scientific Discoveries Need Interpretation

In the course of the day's work for the editor of a technical magazine, a surprising portion of his time is occupied in searching for information desired by men in the field. The questions asked range in character from the most elementary to the highly technical, from the scientific to the commercial. The sources of technical information should be known and immediately available to every man capable of understanding and using the data. Professional associations, public libraries, technical books, schools, colleges and government bureaus are all reliable sources of information.

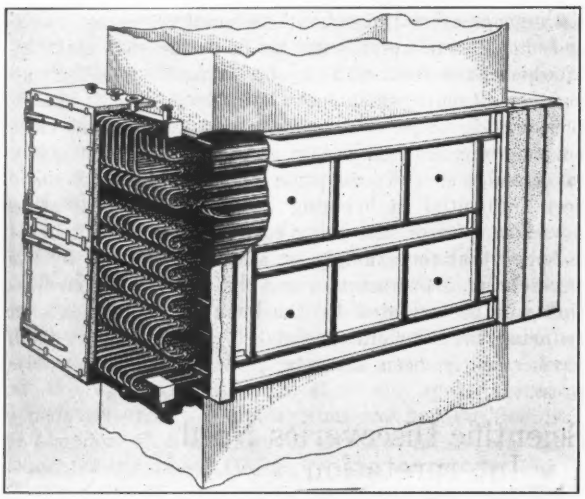
This comment was prompted by the statement recently made by Dr. Alfred D. Flinn, Director of the Engineering Foundation, that inaccessibility of knowledge is the greatest cause of waste and one of the most deplorable of human handicaps. The problem of putting existing knowledge quickly into the hand of the man on the job is, he thinks, one that must be solved by a wider distribution of scientific information.

This problem of quick distribution of scientific information is one with which technical magazines are directly concerned and they are zealous in their endeavor to meet the obligation but it has seemed to us that a greater need is the interpretation of scientific discoveries to the industry. Scientific discoveries may be only laboratory toys for the amusement of a few intellectuals until an Edison, a Sperry or a Westinghouse turn them into the service of mankind in general.

# Power Plant Engineering Developments and News

## Extended-Surface Economizer

RECENTLY the C-E Economizer, fin-tube type, has been placed on the market by Combustion Engineering Corp., New York. The principal features, as shown in the illustration, are the external return bends, the internal return bends, the tube arrangement and the use of finned tubes which provide additional heat-absorbing surface.



ECONOMIZER WITH FIN-TUBES AND RETURN BENDS

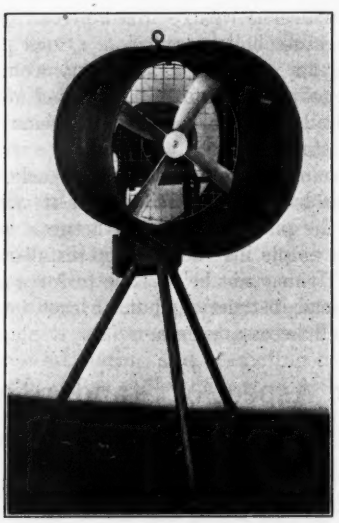
The heat-absorbing elements are constructed by connecting a U-bend to two straight tubes and so forming a U-tube. The open ends of each U-tube are connected serially by return bends located outside the end-plates, to the tubes directly above and below. The adjacent vertical tube sections are arranged so that the open ends of the U-tubes alternately enter one end and the other of the economizer casing. The water circulation is separated into two circuits, one running through the U-tubes connected by the return bends at one end of the economizer and the other through the U-tubes connected by return bends at the opposite end.

Advantage claimed for the two separate water circuits is that the water flows through only one-half the tube distance. With extended surface in the form of fins, the tube length is still further reduced. This, it is stated, results in a material decrease in the frictional resistance. Both circuits are served by common inlet and outlet headers.

Compactness of the unit, it is claimed, is derived principally from the fin-tube design which reduces the tube-length per square foot of heating surface and the return bend arrangement which permits the tubes to be nested closely together. The end plates are designed to permit their being quickly and easily removed for the inspecting and cleaning of the tubes.

## Aeroplane Heat Killer

AEROPLANE HEAT KILLER is the latest type of this equipment to be put on the market by Coppus Engineering Co., Worcester, Mass. Its construction is shown herewith. The No. 1 model includes inlet thimble diffuser with baffle plate in upper part, tripod, starting switch and built in 1-hp. motor running at 1150 r.p.m.



THIS UNIT IS DESIGNED FOR LARGE AIR VOLUMES

The No. 1 is designed to move 10,500 c.f.m. of air at a velocity of 2600 f.p.m. It weighs 250 lb. The No. 2 unit, is designed to handle 15,600 c.f.m. at 3850 f.p.m. It has a 3-hp. motor running at 1750 r.p.m. and weighs 270 lb. This heat killer is designed for use in ventilation in industrial plants, for removing fumes and gases, cooling men or material drying and a variety of uses that readily suggest themselves.

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AFTER MORE than 120 yr. of existence, the first gas tank ever built is still standing at Smethwick, England. The wrought iron cylinder was erected in 1808 by William Murdock, founder of the manufactured gas industry.

# Roller Bearing Sheaves

ROLLER-BEARING SHEAVE or tail block for use in connection with scraper loading or slushing operations, to improve the character of slushing service rendered by Sullivan compressed air and electric portable hoists, has recently been developed by engineers of the Sullivan Machinery Co., Chicago, Ill.

These roller sheaves in 8, 10 and 12-in. diameters, are designed to be heavy and rugged. The sheave itself is made of manganese steel and the side plates are

ROLLER-BEARING SHEAVE OF SNATCH BLOCK CONSTRUCTION

electric steel castings. The swivel hook is made of drop forged alloy steel. A swivel eyebolt may be substituted for the hook if desired. The Hyatt roller bearing supporting the sheave revolves on a hardened steel shaft of large diameter, which is made hollow to serve as a reservoir for lubricant. The sheave is recessed into the side plates prevent the possibility of jamming as well as undue wear on the rope. Snatch block construction has been employed in these sheaves, so that the block may be readily opened by removing a pin. The opening for the rope at the top of the sheave is designed to permit a square knot in the wire rope to pass through without binding.

Lubrication is by improved grease gun fittings. These sheaves are rated at a maximum capacity of 6000 lb. for the 8-in. sheave, 10,000 for 10-in. and 140,000 for the 12-in.

# Link-Belt Introduces Promal Chains

UNDER THE registered trade name of Promal, a new line of cast chains showing remarkable strength and durability has been placed on the market by Link-Belt Co., Indianapolis.

They are the result of extended research to provide longer life for drive and conveyor chains operating under heavy loads or abrasive conditions. Experimentation with cast chain metals led to the discovery of a new method of processing malleable iron which so altered its physical characteristics as to make it a distinctly new metal.

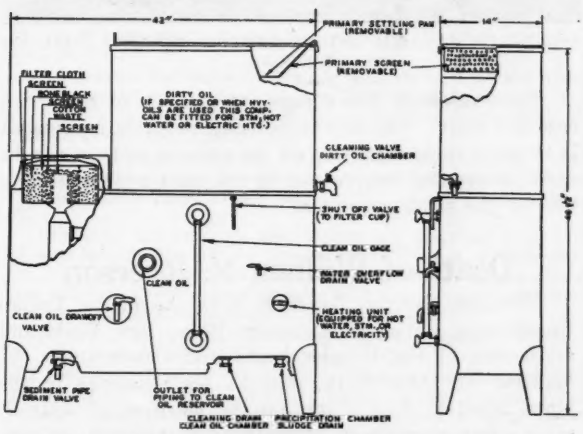
Promal has an average yield point of 45,000 lb.; an average ultimate strength of 65,000 lb.; an average elongation of 14 per cent, and a Brinell hardness of 170-190. Thus it has to a high degree the qualities desirable in sprocket chain material; great toughness to resist extreme tension without permanent stretch; high strength in proportion to weight and size; and hardness that affords great resistance to abrasive wear.

In addition to having this high yield point, Promal metal is tough and ductile so that it withstands shock and fatigue loads. High temperature reduces its tensile properties somewhat, but temperatures up to 1000 deg. F. will not cause it to become brittle.

Following laboratory tests, these chains were tested for over 3 yr. in extension field services and are now particularly recommended by the manufacturer for four general classes of service: (1) chain drives, elevators and conveyors operating under gritty or abrasive conditions; (2) chain drives where greater strength is required than the corresponding size of malleable iron chain provides; (3) drag, scraper and flight conveyors where the chain drags and is subject to abrasion; and (4) heavy duty drives of comparatively high speed, short centers and large sprocket ratios.

# Oil Filter

BURT OIL FILTER shown in sketch was designed primarily for reclamation of crankcase oil but has also been recommended for reclaiming any kind of oil to remove impurities such as sand, dirt, filings, carbon and so on.


42"
14"
PRIMARY SETTLING PAN (REMOVABLE)
PRIMARY SCREEN (REMOVABLE)
FILTER CLOTH SCREEN
BONE BLACK
WASTE COTTON WASTE
SCREEN
DIRTY OIL (IF SPECIFIED OR WHEN HYY-OILS ARE USED THIS COMP. CAN BE FITTED FOR STM. HOT WATER OR ELECTRIC HTG.)
CLEANING VALVE DIRTY OIL CHAMBER
SHUT OFF VALVE (TO FILTER CUP)
CLEAN OIL GAGE
WATER OVERFLOW DRAIN VALVE
CLEAN OIL
HEATING UNIT (EQUIPPED FOR HOT WATER, STM. OR ELECTRICITY)
CLEAN OIL DRAWOFF VALVE
SEDIMENT PIPE DRAIN VALVE
OUTLET FOR PIPING TO CLEAN OIL RESERVOIR
CLEANING DRAIN CLEAN OIL CHAMBER
PRECIPITATION CHAMBER SLUDGE DRAIN

GENERAL VIEW OF FILTER SHOWING POSITION OF CHAMBERS AND FILTERING ELEMENTS

It is designed with four distinct settling chambers and ultimate purification of the oil is by perforated screens, filter cloths, bone black and white waste, as shown in the sketch. The filter is made so that oil will not come in contact with the filtering medium until 75 per cent of the impurities have been removed. The filter is designed to be cleaned quickly and easily and to have high capacity and compactness. It is built without moving parts.

This filter is made by The Burt Mfg. Co., Akron, Ohio, in two sizes, one of 10-20 g.p.h. and the other of 20-40 g.p.h. capacity. The clean oil chambers hold 40 and 80 gal. respectively. The filter occupies 4 sq. ft. of floor space and all valves and connections are easily accessible.

# Versatile Coal Handling System

DESIGNED for versatility and efficiency, the coal handling equipment installed for the Eaton Axle & Spring Co., Cleveland, Ohio, was furnished and installed by the Fairfield Engineering Co., Marion, Ohio.

The layout, as shown, consists of a Type A overtrack feeder placed beneath the rails, a standard 35-ft. portable drag conveyor and a 60-ft. horizontal stationary drag conveyor.

Coal is delivered from the feeder direct to the portable conveyor, thence to the stationary conveyor which extends over the coal bunkers inside the building. This stationary conveyor is fitted with discharge gates to fill uniformly a 60-ft. bunker.

PORTABLE FEEDER AND CONVEYOR SENDING COAL TO BUNKER

The equipment has a capacity of 60 t. of mine run coal per hour. The object in using portable equipment is to move these machines on the outside so they can be used for storing reserve coal in the yard and reclaiming this by the same equipment.

## Death of William N. Ryerson

WILLIAM NEWTON RYERSON, president of the Trojan Engineering Corp., 40 Exchange Place, New York, and a director of the Peoples Light and Power Corp., 27 William St., New York, died at his residence in the Hotel Shelton, New York, on the morning of July 7, after a lingering illness of several months.

He was born in New York City, December 7, 1874, and attended the New York Public Schools and Columbia Grammar School, where he was graduated in 1892. He entered the School of Mines at the Columbia University the following year, from which he was graduated in 1896 with the degree of Electrical Engineer.

Following his graduation, Mr. Ryerson was employed by the Sprague Electric Elevator Co., the Western Electric Company, New York, and as assistant to the chief engineer of the Waldorf Astoria Hotel. In October, 1898, he became associated with the Metropolitan Street Railway Co. of New York on construction and power work and substation operation. In October, 1901, he became superintendent of the substations for the Interborough Rapid Transit, with which concern he remained until April, 1905.

Mr. Ryerson then became assistant superintendent of construction for the Niagara Construction Co., and later in the same year superintendent of construction for the Ontario Power Co., Niagara Falls, Ontario, which position he held until January, 1909. Then he left the East to become general manager and chief engineer, and also a director of the Great Northern Power Co., Duluth, Minnesota. He was in this position for over 13 years. About the time the Duluth properties were acquired by the Electric Bond & Share Company, Mr. Ryerson left to form a connection with Day & Zimmerman of Philadelphia, as assistant manager of the Public Utility Management Department.

In January, 1925, the United Gas Improvement Co. of Philadelphia made him assistant to vice president, in charge of operations and engineering. When the Trojan Engineering Corp. was organized in September, 1928, Mr. Ryerson became its President, which position he held at the time of his death. He was a Fellow of the American Institute of Electrical Engineers and a member of the following societies and associations: American Society of Mechanical Engineers, National Electric Light Association, International World Power Conference, American Gas Association, The Engineering Institute of Canada.

# News Notes

REPRODUCTION of the original Niagara Falls Power plant, a model of which now stands in a field adjacent to the old Niagara Falls Power Co.'s stations 1 and 2, has been proposed as one of many exhibits to be staged at the Chicago World's Fair in 1933 to show the advances that have been made during the last hundred years in mechanical engineering.

The recommendation that a replica of the Niagara Falls model be erected at Chicago is contained in a report of the mechanical engineering section of the National Research Council Science Advisory Committee under the direction of which all the mechanical engineering displays will be exhibited at the exposition.

The National Research Council Science Advisory Committee is composed of about 40 leading scientists throughout the country who, under the leadership of Dr. Frank B. Jewett, vice-president of the American Telephone and Telegraph Co., are developing plans for all the science exhibits at the Chicago Fair.

The mechanical engineering section includes W. L. Batt, president of S K F Industries, Inc., New York City, chairman, and the following: William L. Abbott, Commonwealth Edison Co., Chicago; L. P. Alford, vice-president, Ronald Press, New York; K. H. Condit, American Machinist, New York; Prof. R. H. Fernald, University of Pennsylvania; Clarence F. Hirshfeld, Detroit Edison Co.; George A. Horne, Merchant Refrigerating Co., New York; A. L. Kimball, General Electric Co., Schenectady; Dean Dexter S. Kimball, College of Engineering, Cornell University; W. W. Macon, Iron Age, New York; J. C. Oswald, New York Employing Printers' Association; Dean A. A. Potter, Purdue University, Lafayette, Ind.; C. W. Rice, secretary of the American Society of Mechanical Engineers, New York; W. A. Shoudy, New York, and R. V. Wright, secretary, Simmons-Boardman Publishing Co., New York.

BILL (S. 3619) to reorganize the Federal Power Commission became Public Law 412, 71st Congress when President Hoover signed it on June 23. This authorizes the appointment of five full time Commissioners to take over the duties of the old Federal Power Commission which was composed of Secretaries of War, Interior and Agriculture. The reorganization plans provide for an entirely independent staff in the District of Columbia and authorizes the Commission to call upon the President for detail of engineers in the other Government agencies to perform the field work. A term of office of 5 yr. is authorized after the original commissioners have served terms graduated from 1 to 5 yr. The President has named the first chairman, General Edgar Jadwin, former chief of engineers. The Commission will elect his successors to serve during their term of office.

JENKINS BROS., New York, announces the election of James R. White a vice-president of the corporation, also his appointment as director of sales.

CITIES in Illinois operating municipal public utilities are authorized under municipal ownership act to sell their products outside the corporate limits of the town or city, according to an opinion of Oscar Carlstrom, attorney general of Illinois, in response to an inquiry from the Greenville state's attorney, relative to whether or not the city may sell water outside the city limits.

DIAMOND CHAIN & MFG. CO., of Indianapolis, Indiana, announces its new stock drives designed for all standard power applications. The Diamond Stock Drive consists of a Diamond Roller Chain and two Diamond Sprockets, ready to be installed. They are carried in stock by distributors and supply houses in single to quadruple strands, from ¼ to 75 hp., in ratios up to 8.4 to 1 and for motor speeds up to 1750 r.p.m.

ACCORDING to A. Jackson Marshall, secretary, the 54th Convention and Exhibition of the National Electric Light Association will be held in the Atlantic City Auditorium and Convention Hall, Atlantic City, N. J., June 8 to 12, 1931.

TERRY STEAM TURBINE CO., Hartford, Conn., announces the appointment of John J. Somes as manager of its Chicago office. The new location of this office is at Room 556, 20 North Wacker Drive Building, Chicago, Ill.

CHASE BRASS & COPPER CO., INC., announces the opening of its new Pittsburgh warehouse at 855 North Avenue West, Pittsburgh, Pa., on Monday, July 14.

H. D. CARLTON resigned as president of Consolidated Ashcroft Hancock Co., Inc., and as vice-president of Manning, Maxwell & Moore, Inc., on July 3, 1930.

M. H. DETRICK CO., Chicago, Ill., announces the establishment of a branch office at 733 Mayo Bldg., Tulsa, Okla., under the direction of Henry O. Johanson.

ROSS HEATER & MFG. CO., INC., Buffalo, N. Y., announces the new location of its District Office at Room 1518 20 North Wacker Drive, Chicago, Ill. S. Wolff is district manager and R. E. Allen is sales engineer.

C. C. WOOLEY has been appointed a district manager on the north side of Chicago by the Modern Coal Burner Co., 3733 Lincoln Ave., Chicago, Ill. Ray Glaspell, formerly with the Iron Fireman Mfg. Co. and more recently with the Fire King Mfg. Co., has been appointed a district manager on the south side of Chicago. On June 1, J. M. Staub, formerly with Combustioneer, Inc., took over a north side district managership in Chicago for the company, manufacturers of automatic stokers.

ANNOUNCEMENT is made by Cutler-Hammer, Inc., Milwaukee, Wis., that on July 1 it acquired all common stock of Schweitzer & Conrad, Inc., Chicago. Schweitzer & Conrad will continue to operate as an independent manufacturing and selling unit. No changes in organization or personnel will be made except that Beverly L. Worden, president of Cutler-Hammer, has also been elected president of Schweitzer & Conrad. Mr. Conrad and Mr. Schweitzer have been retained as consulting engineers and will continue their interest in the management as members of the Board of Directors. Other members of the new Schweitzer & Conrad board are F. R. Bacon, who is chairman of the Cutler-Hammer board, and F. L. Pierce and Louis A. Lecher, also members of the Cutler-Hammer board.

FULLER LEHIGH CO., Fullerton, Pa., has opened a new sales office in the Candler Building at Atlanta, Ga. J. Mc. C. Hill is in charge.

# Catalog Notes

CATALOG GEA-600A, superseding all previous catalogs issued by General Electric Co., Schenectady, N. Y., with the exception of those dealing with railway, mine and industrial supplies and merchandise products, has been issued. The publication is issued every two years. The book, 2 in. thick, contains 1146 pages, 8 by 10½ in., and is profusely illustrated.

The catalog is thumb-indexed in 16 sections as follows: Generation, wire and cable, distribution transformers, arresters and capacitors, voltage regulators, switching equipment, switchgear, meters and instruments, lighting equipment, motors, motor applications, industrial control, transportation, industrial heating, miscellaneous and indexes. In the indexes, products are classified both by subjects and by catalog numbers.

PROTECTION OF CHIMNEYS from Lightning by use of proper lightning conductors is discussed in a recent illustrated bulletin by The Carl Bajohr Lightning Conductor Co., 4051-57 Keokuk St., St. Louis, Mo. Design of conductors and fittings to resist corrosion by chimney gases and provide sufficient electrical capacity is described. Both standard and Y systems are discussed in detail.

STEAM QUALITY THROUGH CENTRIFIX, a discussion of the evils of wet, dirty steam and how the Centrifix internal steam purifier for boilers is designed to eliminate them, is the subject of Bulletin 153 just issued by Centrifix Corp., 3029 Prospect Ave., Cleveland, Ohio. The company also describes, in Bulletin 154, its type R. L. Line Purifier designed for installation in steam lines to eliminate dirt, oil and water from steam.

FLOW OF WATER in Drainage Channels, the results of experiments to determine the roughness coefficient in Kutter's Formula, by C. C. Ramser, drainage engineer, division of Agricultural Engineering, Bureau of Public Roads, is issued as Technical Bulletin 129 by U. S. Department of Agriculture. It is priced at 40 cents and may be obtained from the Superintendent of Documents, Washington, D. C.

TYPE C three-drum boiler, a new design for restricted space conditions, is described and illustrated in a recent 8-page bulletin by Erie City Iron Works, Erie, Pa. Details of various settings of the boiler are given. It may be had in sizes from 800 sq. ft. to 6000 sq. ft. Monolithic baffling, steel plate rear wall, structural framework are described.

RELATIVE HUMIDITY RECORDER and its operation are described in Bulletin No. 880 just issued by Leeds & Northrup Co., 4901 Steuton Ave., Philadelphia, Pa. This device employs the principle of measuring the difference between readings of wet and dry bulb thermometers in a current of air. Instead of having to read the corresponding relative humidity from a table, however, the new recorder is designed to register relative humidity direct. The bulletin tells in detail how this is accomplished.

SMITH-KAPLAN Automatically Adjustable Blade Hydraulic Turbines are described in a 24-page bulletin, No. 123, illustrated with half-tones and colored drawings, just issued by S. Morgan Smith Co., York, Pa. Details of the runner and blade actuating mechanism are shown, advantages and efficiencies are discussed, means of regulation from the governor, methods of setting and views of installations are given.

BOILER WATER IMPURITIES, their control by the continuous blow-down system is the title of a recent 28-page illustrated bulletin issued by Henszey De-Concentrator Co., Watertown, Wis. This contains a discussion by Roy O. Henszey of boiler water troubles, impurities, water analysis and conditioning.

PENNSYLVANIA CENTRIFUGAL PUMPS, double suction, single stage are described and illustrated in detail in Bulletin No. 215 by Pennsylvania Pump & Compressor Co., Easton, Pa. Details of parts, types of drive, performance data and installations are shown.

STEEL PLATE CONDENSER SHELLS in Marine Practice, by George R. McDermott, an investigation of their service and length of life, is published in bulletin form by Ross Heater & Mfg. Co., Inc., Buffalo, N. Y.

APPARATUS FOR ELIMINATING and Recovering Dirt and Dust, such as centrifugal washers, gas scrubbers, scrubber washers, are described in a recent 8-page illustrated bulletin, Form 2676, by Buffalo Forge Co., Buffalo, N. Y.

THREE MODELS of Exhaust Temperature Pyrometers for Diesel and oil engine use are described in a recent bulletin, No. 529, by Illinois Testing Laboratories, Inc., 141 W. Austin Ave., Chicago, Ill.

REDUCING VALVES AND REGULATORS are described in a new 20-page bulletin, No. 8-R, by Schutte & Koerting Co., Philadelphia, Pa. The motor-operated Venturi reducing valve is shown, also a new balanced Venturi reducing valve with self-contained regulator. Tables of dimensions, prices and weights are given.

PUMPING MACHINERY of various types is described and illustrated in Bulletin No. 110, just issued by Guild & Garrison, Inc., 457 Kent Ave., Brooklyn, New York. Data on capacities and sizes are given for standard flywheel duplex vacuum pumps surge vacuum pumps, direct-acting pumps for various services piston blowers, Davidson centrifugal and sump pumps.

JOHNS-MANVILLE SERVICE TO THE POWER PLANT, a 64-page well illustrated bulletin just issued by Johns-Manville, 292 Madison Ave., New York, discusses the various products of the company and the way they are used. Section I discusses applications of material for boiler settings duct, pumps and machinery, section II insulating materials and section III other materials such as waterproofing, packing, asbestos products, and the like. Many drawings show details of application of materials and a great deal of valuable engineering information is given.

SCIENTIFIC WATER CORRECTION is the title of an attractive 86-page cloth-bound book just published by Dearborn Chemical Co., 310 So. Michigan Ave., Chicago, Ill. The Dearborn organization is described, then a discussion is given of water analyses, scale formation, removal of scale deposits, corrosion, foaming and priming and embrittlement. Various methods of treating water and some of the equipment used are then discussed.

ELECTRIC LIGHT & POWER, a survey of world development, is being issued by Pynchon & Co., 111 Broadway, New York. This discusses significant developments in the power industries of each country gives total power production installed capacity, potential resources and other data on each and constitutes one of the most exhaustive studies that has ever been made of the world power situation.

# Power Plant Construction News

**Ala., Headland**—The Alabama Power Co., Birmingham, has acquired the local municipal electric light and power plant and is said to be planning expansion and improvements in this district, including transmission line construction.

**Ark., Stuttgart**—The Hoevels Elevator & Storage Co., recently organized by J. C. Robbins and G. E. Hammans, Stuttgart, plans installation of electric power equipment in proposed new rice and cotton elevator, project to cost about $100,000.

**Ark., Texarkana**—J. R. Greenwood, head of the Greenwood Realty Co., and associates, are planning the construction of an ice-manufacturing and cold storage plant on West Seventh Street, reported to cost about $35,000, with equipment.

**Calif., Beverly Hills**—The City Council is arranging a fund of $75,000 for the installation of a water treating plant for municipal waterworks. Salisbury, Bradshaw & Taylor, Petroleum Securities Building, Los Angeles, are consulting engineers.

**Calif., Dorris**—The Kesterson Lumber Co., plans installation of electric power equipment in connection with proposed rebuilding of portion of lumber mill, recently destroyed by fire, with loss reported in excess of $200,000.

**Calif., Susanville**—The California Utilities Co., is planning early rebuilding of local power substation, recently destroyed by fire, reported to cost about $35,000.

**Colo., Denver**—The Midland Oil Refining Co., Midland Savings Bank Building, plans installation of electric power equipment in proposed oil refining plant, in the vicinity of West Third Avenue, entire project to cost about $225,000.

**Conn., New Haven**—The National Folding Box Co., James Street, will install electric power equipment in proposed new four-story and basement factory addition, 85x175 ft., to cost upward of $150,000. Fletcher-Thompson, Inc., 542 Fairfield Avenue, Bridgeport, is architect and engineer.

**Idaho, Soda Springs**—The City Council is planning a municipal hydroelectric generating station to cost about $30,000. A special election has been called on July 29, to vote bonds in amount noted.

**Ind., Indianapolis**—The Indianapolis Power & Light Co. will build a new steam-operated electric generating plant on Harding Street, and is securing a right of way for a proposed transmission line around the city, entire project reported to cost over $5,000,000.

**Ind., Lafayette**—The Board of Trustees, Purdue University, will have plans drawn for an electrical engineering building at the institution to cost over $100,000.

**Ind., Muncie**—The Warner Gear Co., plans installation of electric power equipment in proposed new plant unit on tract of land, recently acquired near city, entire project to cost close to $2,000,000.

**Iowa, Council Bluffs**—The Council Bluffs Gas Co., plans rebuilding of portion of gas plant, recently destroyed by fire with loss reported about $25,000.

**Iowa, Nevada**—The Iowa Railway & Light Corporation, Cedar Rapids, has plans maturing for a new power plant at Nevada, estimated to cost about $175,000.

**Kans., Independence**—The City Council is planning the installation of additional equipment in municipal electric light and power plant, including a 400 kw. Diesel engine unit and accessories. Charles L. King is city clerk.

**Kans., Wichita**—The Stearman Aircraft Corporation, 601 East Thirty-fifth Street, plans construction of a one-story power house in connection with new local aircraft manufacturing plant, entire project to cost over $400,000.

**Mass., Boston**—The Edison Electric Illuminating Co., 39 Boyleston Street, is awarding miscellaneous building contracts for an addition to its power substation No. 8, at East Boston, reported to cost over $40,000.

**Mich., Traverse City**—The Michigan Public Service Co., Ludington, will proceed with the construction of a new electric power plant on the Boardman River, near Traverse City, reported to cost more than $350,000, with transmission lines.

**Minn., St. Paul**—The Farmers Union Terminal Association, Minnesota Building, M. W. Thatcher, manager, plans installation of electric power equipment, in proposed addition to grain elevator at the foot of Chestnut Street, to cost about $100,000.

**Miss., Prentice**—The Town Council is said to be planning the early purchase of an oil-operated engine and auxiliary equipment for municipal power service.

**Mo., Kansas City**—The Colgate-Palmolive-Peet Co., Seventh and Kansas Streets, will install electric power equipment in new addition to soap-manufacturing plant, reported to cost about $125,000, for which plans have been filed.

**Mo., St. Joseph**—The St. Joseph Railway, Light, Heat & Power Co., Sixth and Francis Streets, is completing plans for a two-story and basement equipment storage and distributing plant to cost about $60,000. Walter Boschen, Tootle-Lacy Building, is architect.

**Mo., St. Louis**—The St. Louis Portland Cement Co., care of C. Boettcher, president, Ideal Cement Co., Denver, Colo., recently organized by Mr. Boettcher and associates, plans installation of power equipment in proposed new cement mill in St. Louis district, entire project to cost over $1,500,000. A power house will be built.

**N. J., Bound Brook**—The Bakelite Corporation, 247 Park Avenue, New York, plans construction of one-story power plant, 50x100 ft., at new mill on site recently acquired at Bound Brook, for manufacture of composition products, entire project to cost over $1,000,000. Francisco & Jacobus, 511 Fifth Avenue, New York, are architects and engineers.

**N. Y., Endicott**—The International Business Machines Corporation will install electric power equipment in new addition to local plant to cost about $100,000, for which superstructure will proceed at once.

**N. Y., Mineola**—The Board of Nassau County Supervisors has authorized the construction of a one-story power plant to cost over $100,000, in connection with a new local county hospital to cost more than $1,500,000.

**N. Y., New York**—The Lehigh Valley Railroad Co., 143 Liberty Street, will install electric power equipment, conveying, elevating and other mechanical-handling equipment in new fifteen-story freight terminal at Eleventh Avenue and Twenty-sixth Street, entire project to cost over $7,500,000. Russell G. Cory, 30 Church Street, is architect and engineer.

**Ohio, Cleveland**—The W. S. Tyler Co., 3613 Superior Avenue, plans installation of electric power equipment in new addition to screen and wire cloth manufacturing plant, entire project to cost over $100,000. George S. Rider Co., Marshall Building, is architect and engineer.

**Okla., El Reno**—The City Council is considering special election at an early date to vote bonds for $450,000, for proposed municipal electric light and power plant. J. H. Bender is city manager.

**Pa., Philadelphia**—The Aviation Corporation of the Americas, 122 East Forty-second Street, New York, plans installation of electric power equipment in proposed seaplane manufacturng plant at the Hog Island marine terminal, Philadelphia, entire project reported to cost over $350,000. Negotiations for site are under way.

**Pa., Pittsburgh**—The Jones & Laughlin Steel Corporation, Pittsburgh, plans installation of electric power equipment in connection with an expansion and improvement program at mills to cost close to $20,000,000, over a period of months.

**Texas, Galveston**—The Galveston Electric Co., is said to be planning extensions and improvements in power plant on Twenty-sixth Street, to cost about $75,000.

**Va., Winchester**—The H. J. Heinz Co., 1062 Progress Street, Pittsburgh, Pa., plans installation of electric power equipment in proposed new food products canning plant at Winchester, entire project to cost over $100,000. A boiler plant is projected.

**Wash., Seattle**—The Ford Motor Co., Dearborn, Mich., plans construction of a power house at proposed new assembling plant at Seattle, for which work will begin at an early date. Entire project will cost close to $1,000,000. Albert Kahn, Inc., Marquette Building, Detroit, is architect and engineer.

**Wis., Fond du Lac**—The George H. Hormel Co., Austin, Minn., has approved plans for a one-story cold storage and distributing plant, on West Scott Street, Fond du Lac, reported to cost about $40,000.